GREEN SOLUTIONS FOR WET WEATHER MANAGEMENT
A RESEARCH THESIS

Presented in fulfillment of the requirements to graduate with research distinction from the Civil Environmental and Geodetic Engineering Department at The Ohio State University.

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ABSTRACT

Managing storm runoff and sewer overflow remains one of the largest challenges of sustainable environmental design for cities. Combined Sewer Overflows (CSO) can be mitigated by means of “green” infrastructure. A CSO results when a major rain event causes a storm surge within the cities network of combined sewers. A combined sewer houses the flow of both sanitary and storm water. These CSOs are harmful to the environment as they release waste water into natural ecosystems when the system is overflowing with storm water. “Green” infrastructure solutions for CSOs have been developed and implemented into various cities around the country, yet little has been done to quantify and objectively forecast their potential effects.

Green infrastructure can be defined as any form of storm water capture and retention prior to its introduction into a sewer network. Examples of green infrastructure include but are not limited to: green roofs, permeable pavements, cisterns, rain gardens and vegetated swales. The implementation of green infrastructure relies heavily on the characteristics of the land and the built environment. Using the city of Columbus as a test case, we categorized a scheme of green infrastructure scenarios based on varying attributes of the city landscape. We segmented the city into discrete catchments and categorized them based of surface type, size, drainage and topographic slope. For each catchment type we compare simulations with and without different "green" solutions. We applied the USGS Technical Release 55 method (TR-55) to determine the peak unit discharge of runoff before and after the implementation of green infrastructure in each sub-catchment type. Our simulation results show that the

implementation of green infrastructure will serve to limit peak discharge and total volume of runoff and thus prevent much storm water from overflowing the sewer network.

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CHAPTER 1

1.0 INTRODUCTION

1.1 OVERVIEW

Conventional development practices cover large areas with impervious surfaces such as roads, driveways, and buildings. Once such development occurs, rainwater cannot infiltrate into the ground. Instead, it runs off the land at much higher levels than would naturally occur. The collective force of this runoff scours streams, erodes stream banks, and carries large quantities of sediment and other pollutants into water bodies each time it rains. In addition, the storm runoff that makes it into a sewer often results in a combined sewer overflow (CSO). A CSO results when a major rain event causes a storm surge within the cities network of combined sewers. A combined sewer houses the flow of both sanitary and storm water. These CSOs are harmful to the environment as they release waste water into natural ecosystems when the system is overflowing with storm water. The storm surges can be attributed to the massive peak discharges of runoff rain water; furthermore, the ubiquitous paved, impervious surfaces created in and around cities facilitate these events. Discharges from CSOs during rain events contain high loadings of problem contaminants such as suspended solids, oxygen demanding organics and pathogenic microorganisms (Field 2001). These constituents degrade water quality and pose threats to human and biological life that depend on natural water ways. CSOs and large surges of untreated storm runoff are among the major sources responsible for beach closings, shell fishing restrictions, and other water body impairments. Management of wet weather flow is a top priority for the United States Environmental Protection Agency (EPA). They estimate that almost 800 cities containing 40 million people in the United States have combined sewer systems that experience CSOs (EPA, 2012). There is a growing need for research that seeks to analyze alternative, sustainable methods to CSO prevention and treatment of storm water runoff; moreover, these alternative methods, known as “green” infrastructure, have been developed and implemented into a few progressive cities around the country. Despite these new developments in wet weather management, however, most communities and cities still remain dependent on 20th century techniques, e.g. upsizing of conveyance piping or housing of storm flow; this is known as “grey” infrastructure.

Green infrastructure can be defined as any form of storm water capture and retention prior to its introduction into a sewer network. Examples of green infrastructure include but are not limited to: green roofs, permeable pavements, cisterns, rain gardens and vegetated swales. Each example has its own benefits and drawbacks; furthermore, much green infrastructure can be retrofitted to existing landscapes. Any form of new construction is required to develop an Environmental Impact Study. The United States were front-runners in ideas to negate impacts of new construction in creating the National Environmental Policy Act (NEPA) of 1969. NEPA declared a national policy to “encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere… to enrich the understanding of the ecological systems and natural resources; and to establish a Council on Environmental Quality”(Davis 164). Clearly from this text, it can be demonstrated that the U.S. Congress recognizes the profound impact man has on his environment. The implementation of green infrastructure is one such method of fulfilling NEPA and ensuring sound management of storm runoff.

1.2 Scope and Objectives

The focus of this research is to determine if green infrastructure will limit the amount of storm water runoff that reaches a city's sewer network. The city of Columbus is used as a case study. Green infrastructure relies heavily on the characteristics of the built environment, and analysis must be done on a case by case scenario. The peak discharge and total runoff volume is determined by a series of calculations known as the United States Department of Agriculture (USDA) Urban Hydrology for small Watersheds Technical Release 55 (TR-55). Using the TR-55, peak discharges and total runoff volume were determined for a study area within the city of Columbus, see figure 1.

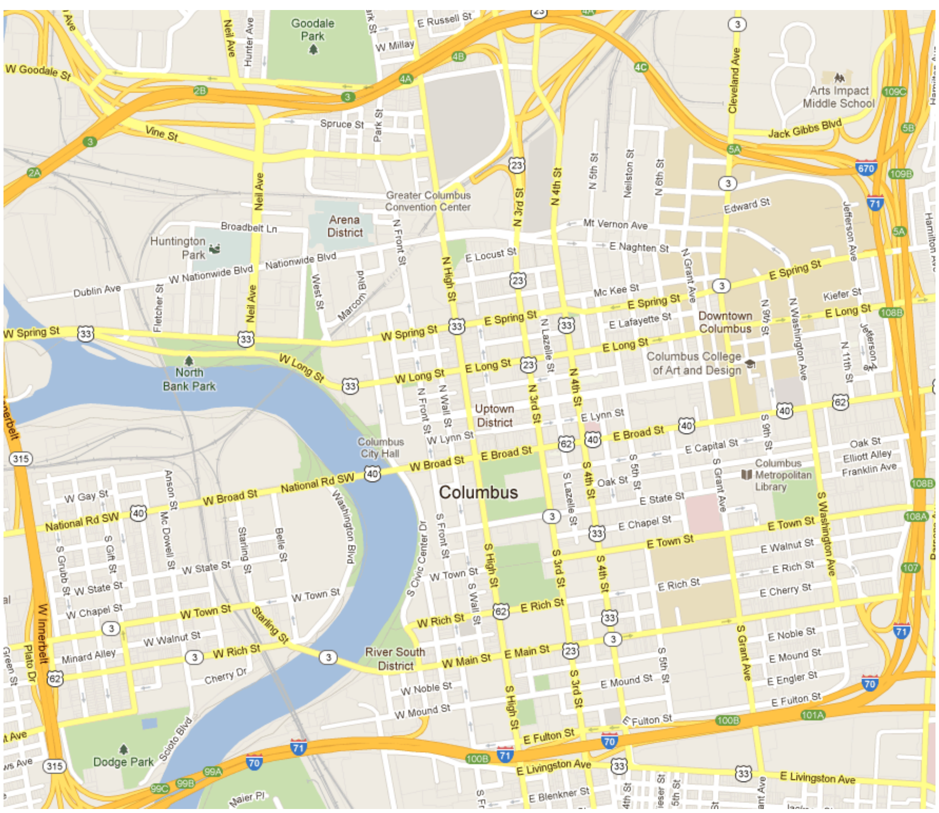


Figure 1: Study area for application of TR-55. The research focuses on applications of green infrastructure within urban areas. This study area was used in GIS ArcMap in order to determine the inputs to the TR-55 method. GIS shp files were obtained from the Franklin County auditor's map room

The study area was considered to be the most urbanized area of the city of Columbus. The research boundaries were considered the loop of highways that circle the downtown area, these are: I70 to the south, I71 to the east, I670 to the north, and 315 to the west.

A range of green infrastructure scenarios were implemented into this study area and peak discharges/total runoff volume was once again calculated. A wide range of 24hr storms were tested. The calculated runoff values are analyzed and compared with the results from the green infrastructure scenarios. The accuracy of the calculations will also be discussed. The theory of the TR-55 and wet weather management is discussed. Finally, guidelines for green infrastructure implementation are developed.

The objectives of this research are:

- Describe the method for calculating peak discharge and storm runoff volume
- Analyze the peak discharges/total volume with and without green infrastructure scenarios
- Determine the relationship between green infrastructure and mitigated peak discharge/total volume of runoff
- Discuss benefits and guidelines for green infrastructure implementation

1.3 Literature Review

This research was heavily influenced by the TR-55 method for modeling runoff. TR-55 presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. The procedures are applicable in small watersheds, especially urbanized watersheds, within the United States. The TR-55 was first issued by the Soil Conservation Service (SCS) in January 1975. TR-55 contains limitations that will only be addressed in this section; furthermore, the limitations of TR-55 span a wide range and many will be ignored or are not applicable to this research. The need for using TR-55 is on a comparative basis for different land cover scenarios. Everything being equal, the limitations will cancel out between comparison of the control and green infrastructure scenarios. Due to the limitations and scale of the project, the values found in this research may not be representative of actual runoff values measured within the city of Columbus' sewer network.

The topography for TR-55 needs to be of suitable quality to properly evaluate subwatershed area limits. The topography for this research was obtained from the Franklin County Auditor's map room and was assumed to be accurate. The topography map provided two foot contours and was integrated into GIS ArcMap, the geo-referencing software used in this research. At no point was the topography field tested for accuracy. TR-55 requires the delineation of ground cover types. A site visit helps with this process. Due to the scale of this research, no site visits were conducted. The ground cover types were determined from the aerial imaging of the city of Columbus provided by the Franklin County Auditor's map room. The study area mainly consisted of impervious surfaces that warranted this method. TR-55 requires the proper soil hydrologic group. The SCS soil survey was relied upon for this information. Upon consideration of the scope, complexity, available data, and acceptable level of error, TR-55 was determined to be the best available practice (BAP) for determining storm water runoff volume and peak discharge.

1.4 ORGANIZATION

The research thesis begins with an introduction discussing the need for research and objectives outlined at the inception of the project. Chapter 2 provides the TR-55 guidelines for runoff modeling and the application of the method to the research study area. Chapter 3 addresses the model details and testing procedure for determining total volume runoff and peak discharge values. Chapter 4 describes the analysis of the model findings based on a wide range of green infrastructure scenarios tested for rain events ranging up to a 24hr 100yr storm. Finally, Chapter 5 provides the summary and conclusion for the research as well as benefits and guidelines for green infrastructure implementation.

CHAPTER 2

2.0 TR-55 PROCEDURE FOR RUNOFF MODELING

2.1 INTRODUCTION

TR-55 analysis begins with a rainfall amount uniformly imposed on the watershed over a specified time distribution. Rainfall is converted to runoff by using a weighted runoff curve number (CN). CN is determined by soil type, plant cover, impervious area, interception, and storage, all characteristics of infiltration. Each area in using the TR-55 is referred to as a "catchment"; each catchment is composed of "patches," which are each assigned a CN. TR-55 includes four regional 24hr rainfall time distributions. The study area for this research falls into category II as determined by SCS. The process of using TR-55 for a type II urban region is as follows: estimate runoff using Curve Number method, calculate time of concentration and travel time, and lastly use the Tabular Hydrograph method to find peak discharge.

2.2 Estimating Runoff

The SCS Runoff CN method is used to estimate runoff. The SCS runoff equation is:

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S} \tag{1}$$

Where: Q = runoff (in), P = rainfall (in), S = potential max retention (in), and I_a= initial abstraction (in)

The initial abstraction (I_a) is all losses before runoff begins and can be computed as:

$$Ia = 0.2S \tag{2}$$

The parameter S is related to the soil and cover conditions associated with the CN:

$$S = \frac{1000}{CN} - 10 \tag{3}$$

CN has a range of 0 to 100 and are tabulated, see table 1. The study area falls into hydrologic soil group C as determined from a SCS soil survey report. For each catchment a weighted CN was derived from the individual CN's of the patches that made up that catchment. This weighted CN was then used in equation 3.

$$CN = \frac{1}{A_t}(CN_1 A_1 + CN_2 A_2 + \cdots + CN_n A_n) \tag{4}$$

Where: CN = weighted CN used, A_t = total area of catchment, CN_n = CN for patch, A_n = area for patch.

Table 2: Curve Number Determination for TR-55. This table provides Curve Numbers for a range of surface types. The hydrologic soil group for this research is group C. Curve Numbers are smaller for pervious surfaces and larger for impervious surfaces.

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

Source http://www.cpesc.org/reference/tr55.pdf

2.3 Time of Concentration and Travel Time

Time of concentration (T_c) is the time for runoff to travel from the hydraulically most distant point of the catchment to a point of interest. Travel time (T_t) is the time it takes a single drop of water to travel from one location to another within a watershed. Travel time is a component of time of concentration; time of concentration is the sum of all travel times for consecutive components of the drainage conveyance system. Generally, travel time is decreased in urban watershed as a result of less resistance to flow. Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or a combination of the three. The type that occurs is determined by field inspection of the land surface. For this research model only sheet flow and shallow concentrated flow were considered. Any channel flow was considered not to run to a sewer network, and thus would not play a role in CSOs. The rule of thumb used gave a maximum length of 300 feet to sheet flow. Once this threshold was met, flows were calculated as shallow concentrated flow until they reached a point of interest. Time of concentration was calculated as follows:

$$T_c = T_{t1} + T_{t2} + \cdots T_{tm} \tag{5}$$

Where: T_c = time of concentration (hr), T_t = travel time, m = number of flow segments.

2.3A Sheet Flow

Sheet flow is flow over plane surfaces; sheet flow also occurs in the headwater of streams. To calculate sheet flow, the friction value, known as the Manning's roughness coefficient, is determined by inspection. Manning's roughness coefficient (n) accounts for the effect of raindrop impact, drag over the surface, obstacles, crop ridges, erosion, rocks, and transportation of sediment. Table 2 provides Manning's n values for sheet flow for various surface conditions.

Table 3: Mannings Coefficients. This table provides a manning roughness coefficient for a range of surfaces. The coefficient is used in the Manning's kinematic solution for calculating sheet flow.

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source http://www.cpesc.org/reference/tr55.pdf

For sheet flow less than 300 feet, Manning's kinematic solution for shallow flow was used to compute travel times.

$$T_t = \frac{0.007(nL)^{0.8}}{P^{0.5}} \frac{1}{s^{0.4}} \tag{6}$$

Where: T_t = travel time (hr.), n = manning's roughness coefficient, L = flow length (ft), P = rainfall (in), s = slope of hydraulic grade line (ft/ft).

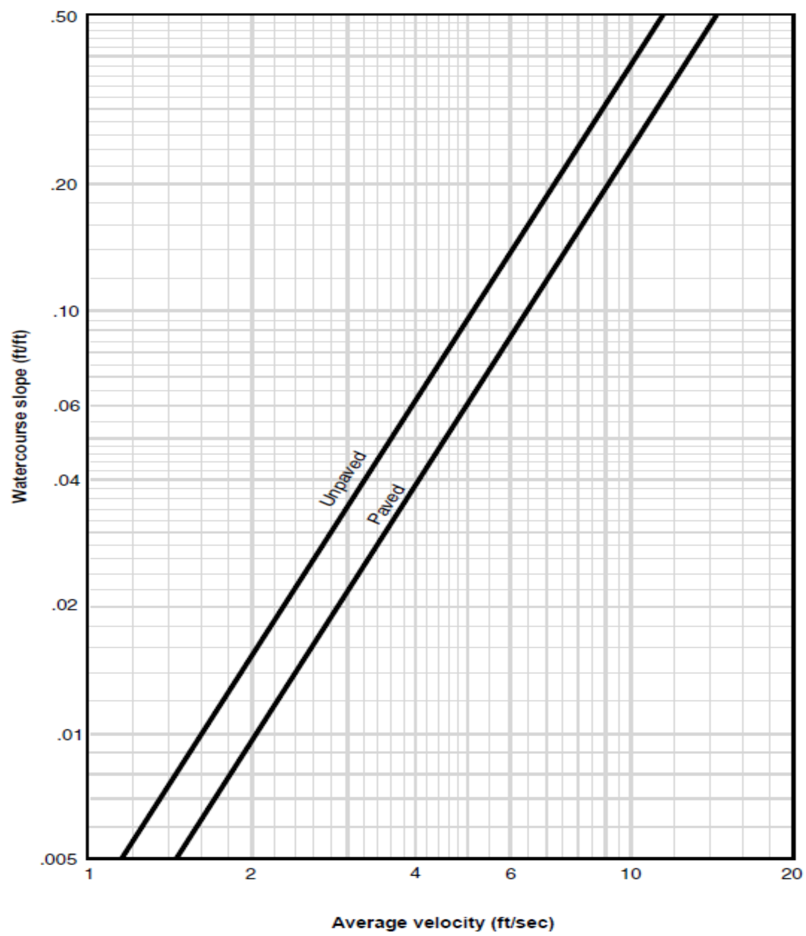
The above represents a simplified form of Manning's kinematic solution based on: shallow uniform flow, constant intensity of rainfall, rainfall duration of 24 hours, and minor effects of infiltration on travel time.

2.3B Shallow Concentrated Flow

After a maximum of 300 feet, sheet flow was assumed to become shallow concentrated flow. The average velocity for this flow was determined from figure 2. The average velocity is a function of watercourse slope and type of channel. After determining average velocity, the following was used to calculate travel time:

$$T_t = \frac{L}{3600\,V} \tag{7}$$

Where: T_t = travel time (hr.), L = flow length (ft), V = average velocity (ft/s), 3600 = conversion from seconds to hours.



source:http://www.cpesc.org/reference/tr55.pdf

Figure 2: Average Velocity as a function of slope. This figure was used in determining average velocities for shallow concentrated flow within the study area. Given the slope and type of surface, the average velocity is readily computed within the TR-55 model.

2.4 Tabular Hydrograph Method

The Tabular Hydrograph method develops partial composite hydrographs at any point in a watershed by dividing the watershed into homogeneous subareas; therefore, the research study area of nonhomogeneous catchments divided into homogeneous patches was a good fit for this method. This method approximates TR-20, a more detailed hydrograph procedure. The input needed for this method include: 24-hour rainfall, appropriate rainfall distribution, CN, T_c

(hr), T_t (hr), and drainage area (mi^2). Appendix A shows tabular discharge values for the various rainfall distributions of concern. The discharges are expressed in csm/in (cubic feet of discharge per second per square mile of water shed per inch of runoff). The discharges are given for a range of patch T_c's and T_t's. The tabular discharges were developed by the USDA by computing hydrographs for 1 square mile of drainage area for selected T_c's and routing them through stream reaches with the range of T_t's indicated. The following information is required for use of the Tabular method:

1. Subdivision of the Catchment into homogeneous patches that have convenient routing reaches.
2. Drainage area of each patch in square miles.
3. T_c for each patch in hours.
4. T_t for each routing reach in hours.
5. CN for each patch
6. Appropriate rainfall distribution
7. 24-hour rainfall amount in inches
8. Total runoff (Q) in inches
9. I_a for each catchment
10. Ratio of I_a/P for each catchment

The calculation of the above parameters were either calculated in the previous section or will be described in Chapter 3. The hydrograph coordinate for each patch is determined from the travel time and time of concentration for its appropriate catchment and corresponding I_a/P value. The peak flow for each patch is found by the following equation:

$$q = q_t A_m Q \tag{8}$$

Where: q = peak discharge (cfs), q_t = tabular hydrograph unit discharge, A_m = drainage area of patch (mi^2), Q = runoff (in)

CHAPTER 3

3.0 MODEL DETAILS AND TESTING PROCEDURE

3.1 Model Review

A wide variety of models currently exist that integrate the TR-55 methodology; for example, HydroCad, Bentley Systems, Eagle Point and Intellisolve. Drainage diagrams must be provided for these models along with a wide variety of inputs. Typical models of this sophistication are used on a site by site basis. It was necessary for this research to have a model that was easily integrated with GIS ArcMap so that the study area could easily be integrated. It was also necessary for the model to be easily manipulated in order to test the effects of green infrastructure. For this reason, a simplified model following closely the procedures of TR-55 was coded in MATLAB. MATLAB is a programming tool for algorithm development, data analysis, and numerical computation. Upon completion of the TR-55 coded program, information from GIS was readily computed and made available for analysis.

3.2 GIS ArcMap

A geographic information system (GIS) allows the visualization of spatial data. ArcMap is a mapping and data manipulation tool used for map-based tasks including cartography, map analysis, feature selection, and editing. GIS ArcMap files are stored in the ".shp" format. The Franklin county auditor's map room provides shp files of the county to the public for a small fee. GIS ArcMap was used in this research to develop an infrastructure table that could be integrated into our TR-55 model. The requirements for TR-55 were outlined in chapter 2. A section of the infrastructure table is shown in Table 3**,** and the corresponding map is shown in Figure 3. The entire infrastructure table for the study area can be found in Appendix B.

Table 4: Infrastructure Table. Below is a section of the infrastructure table that was derived in GIS ArcMap. Each patch was given a distinct Catchment ID, and Patch ID. The surface ID was based on the surface type and can be found in Table 4. The area is in square miles, length in feet, and slope in ft/ft. Pond represent the fraction of the patch that could impound water.

CatchID	PatchID	SurfTyID	Area	Length	Slope	Pond
1	1	2	0.013138538	186	0.09677419	0
1	2	4	0.004030922	1377	0.00290487	0
1	3	4	0.040193845	2239	0.00267977	0
1	4	3	0.002680109	440	0.00909091	0
1	5	3	0.002156478	811	0.00493218	0
1	6	4	0.01810403	1653	0.00725953	0
1	7	2	0.011344475	2085	0.00383693	0
1	8	3	0.010442072	448	0.01339286	0
1	9	4	0.019871858	1231	0.00324939	0
1	11	5	0.033199083	2056	0.00486381	0
1	10	5	0.006243195	861	0.00232288	0
2	1	4	0.13924558	2950	0.00067797	0
2	2	5	0.124964369	3480	0.00114943	0
2	3	3	0.004358303	822	0.00243309	0

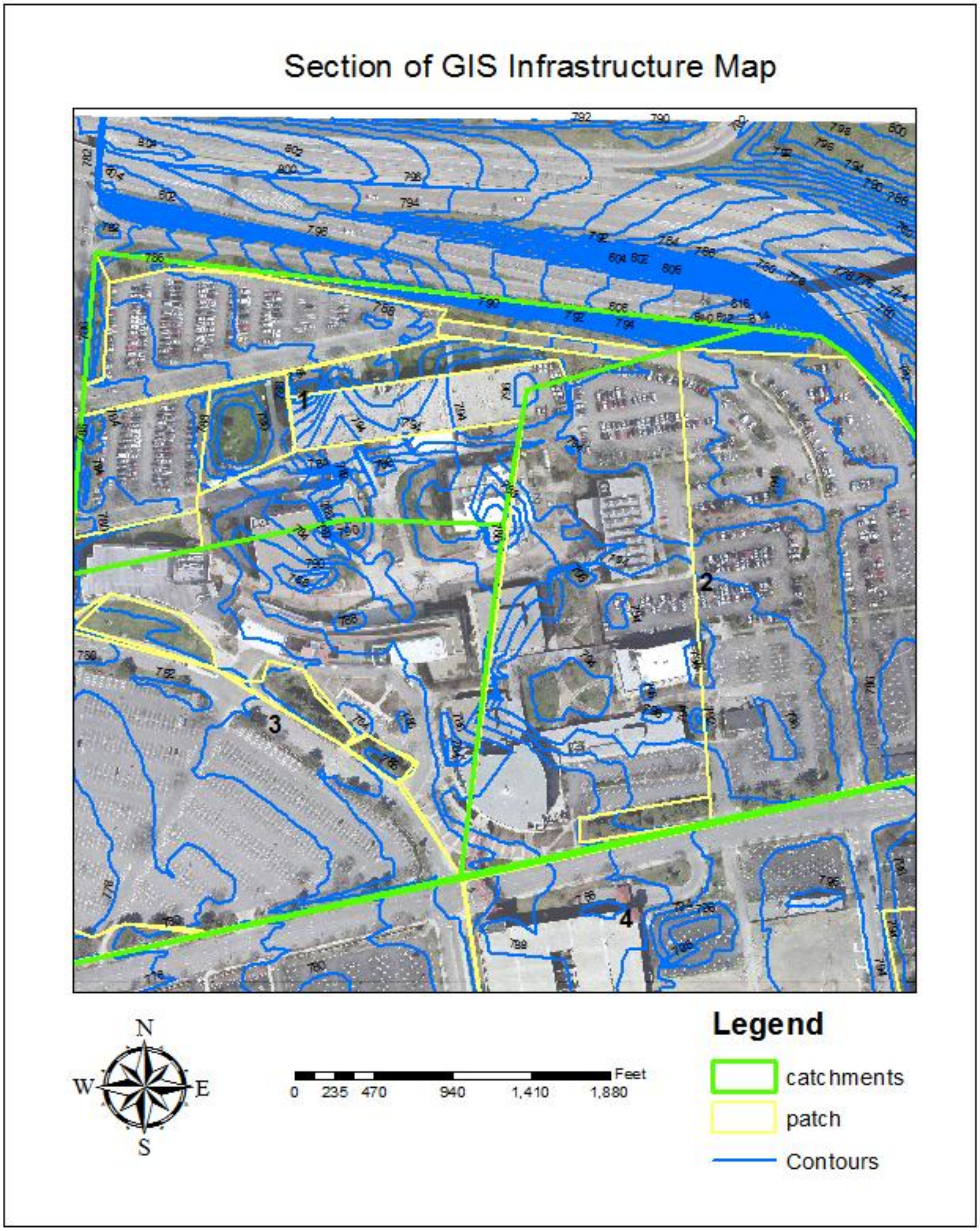


Figure 3: Section of GIS Infrastructure Map. Above is a section of the study area used in GIS ArcMap. Catchments were determined by land area and topography; catchments 1, 2, and 3 can be seen on this map. Patches were classified by surface types. The contours provided the slope of each individual patch. The entire study area consisted of 166 distinct catchments.

The CatchID, PatchID, and SurfTyID, refer to the Catchment ID, Patch ID, and Surface Type ID. These values were imputed manually. Each patch was given a unique Catchment and Patch ID so as to insure accuracy and consistency within the TR-55 model. The Surface Type ID was assigned to each patch based on inspection of the surface within GIS. The Surface Type ID's can be seen in Table 4. The assigned surface type ID's allowed for the model to assign a CN and Manning's coefficient to each patch. The area (mi^2), length (ft) and slope (ft/ft) of Table 3 were readily calculated in GIS via its geometry tool. The pond factor is based on the percentage of area within each patch that was considered a pond or able to retain water.

Table 5: Surface Type. Each patch was given a Surface ID that corresponds to a Curve Number and Mannings Coefficient of roughness. These values are found in Table 1 and 2.

Surface Type	Surface ID	Curve Number	Mannings Coef
Open space poor	1	86	0.06
open space fair	2	79	0.17
open space good	3	74	0.24
Paved parkinglot and building	4	98	0.011
Urban Area	5	94	0.011
Residential (1/4 acre)	6	83	0.15
Residential (1/2 acre)	7	80	0.15
Residential (> 1 acre)	8	79	0.15
Newly graded development	9	91	0.05

3.3 TR-55 Model

The TR-55 procedure outlined in chapter 2 was coded in MATLAB and the infrastructure table described in the previous section is capable of being read into the model. The model's input is the infrastructure table, and the model's output is peak discharge and total volume of runoff. The range of storm events tested for are shown in Table 5.

Table 6: Range of Storm Events. Below is the range of storm events tested for this research. The TR-55 specifications limit the model to 24hr storm events.

P (in)	type of storm
1	control
2	1 yr 24 hr
2.5	2 yr 24 hr
3	5 yr 24 hr
4	25 yr 24 hr
5	100 yr 24 hr

Equations 1-7 were simply programmed directly into the model. Figure 2 was reduced to two separate equations for determining velocities.

$$V_{paved} = 10^{(\mathrm{LOG}(s)+2.5828)/1.947} \qquad (9)$$

$$V_{unpaved} = 10^{(\mathrm{LOG}(s)+2.4051)/1.985} \qquad (10)$$

Where: V = velocity ft/s, s = slope (ft/ft)

The Tabular Hydrograph method was simplified to fit the model. TR-55 procedures include finding peak discharges for the entire range of travel times and then summing over the entire catchment for each iterative travel time. The peak discharge is determined then by creating a newly tabulated hydrograph; therefore, each patch will have its own peak discharge at a certain travel time, but this peak discharge may not necessarily contribute to the peak discharge of the entire catchment. The peak discharge will occur at a certain travel time with varying discharges from each patch. To simplify this procedure, our model assumes peak discharge to be additive for each patch making up the catchment. Considering the vast majority of surface type with in the study area is homogeneously impervious, this assumption is effective. Appendix A was adjusted to find the max tabular hydrograph unit discharge value for each row. This is shown in Table 6. The Ia/P, travel time and travel concentration values were all rounded within the model to fit table 6. This is the TR-55 suggested method as linear interpolation would skew results.

3.4 TR-55 Model Green Infrastructure Scenarios

A separate program was compiled in MATLAB for analysis of the study area with green infrastructure scenarios. The scenarios were based upon a percent reduction in paved, impervious area, ID 4 in table 4, and a corresponding increase in pervious open spaces, ID 3 in table 4. The program worked by manipulating the infrastructure table created in GIS ArcMap. The program was designed so as the input variable is the percent reduction in impervious areas. The output remained the same, peak discharge and total volume of runoff. The range of percent reductions tested are: 5%, 10%, 15%, 20%.

Table 7: Tabular Hydrograph Unit Discharge. The tabular hydrograph method was used for determining peak discharge. The tabular discharge unit is found for each patch and determined by the Ia/P, Travel Time, and Travel Concentration for that patch. The max values are shown in this table and were obtained from the tables in Appendix A.

Ia/P	Travel Time (Tt)	(Tc) 1	(Tc) 2	(Tc) 3	(Tc) 4	(Tc) 5	(Tc) 6	(Tc) 7	(Tc) 8	(Tc) 9	(Tc) 10
0	0	0.1	0.2	0.3	0.4	0.5	0.75	1	1.25	1.5	2
0.1	0	847	733	641	557	499	405	340	297	265	218
0.1	0.15	704	652	587	523	477	391	332	292	259	213
0.1	0.25	662	585	536	486	448	379	323	288	255	211
0.1	0.35	601	551	510	467	434	367	318	282	252	209
0.1	0.45	553	506	475	440	412	358	311	279	249	208
0.1	0.625	464	438	417	393	374	329	293	265	240	202
0.1	0.875	434	413	396	376	359	319	286	261	236	201
0.1	1.25	373	356	347	333	322	295	268	247	226	195
0.1	1.75	336	324	317	306	297	274	252	236	218	190
0.1	2.25	308	298	293	285	278	260	241	226	210	185
0.1	2.75	288	280	275	268	263	247	231	218	204	180
0.3	0	762	600	520	462	416	329	279	247	219	180
0.3	0.15	609	521	468	424	388	321	271	239	213	175
0.3	0.25	563	484	440	403	372	308	264	236	210	174
0.3	0.35	500	436	407	379	354	301	259	232	207	173
0.3	0.45	465	415	389	364	341	292	254	228	205	171
0.3	0.625	381	348	335	321	305	269	239	218	197	167
0.3	0.875	357	331	320	308	295	261	234	214	195	166
0.3	1.25	310	288	281	274	265	241	220	203	187	161
0.3	1.75	279	262	257	252	245	226	209	194	180	157
0.3	2.25	256	242	239	235	230	214	199	187	174	153
0.3	2.75	240	227	224	221	217	205	192	180	169	150
0.5	0	376	305	263	240	216	180	156	140	128	112
0.5	0.15	338	268	236	220	203	173	153	139	128	111
0.5	0.25	285	245	224	209	194	170	150	137	128	111
0.5	0.35	266	228	213	202	189	166	148	136	126	110
0.5	0.45	248	218	203	194	184	162	146	135	126	108
0.5	0.625	213	193	184	177	169	154	140	130	125	108
0.5	0.875	205	186	178	173	166	151	139	129	122	108
0.5	1.25	183	168	163	159	154	143	133	125	121	106
0.5	1.75	168	157	153	150	146	137	129	122	118	104
0.5	2.25	159	148	145	143	140	132	125	119	113	102
0.5	2.75	151	142	139	138	135	128	122	116	111	101

CHAPTER 4

4.0 ANALYSIS

4.1 TOTAL PEAK DISCHARGE

The model was run to output the total peak discharge of the entire study area. The sum of all individual catchments was taken to reach these values. Figure 4 displays the total peak discharge vs. the precipitation amounts shown in table 5. Five scenarios are shown in figure 4: current landscape, 5, 10, 15, and 20% green infrastructure. The figure displays a linear relationship between the precipitation and total peak discharge. This relationship does not change as the percentage of green infrastructure landscape is increased. The reduction in peak discharge vs. percent of green infrastructure used is shown in Figure 5 for the 6 precipitation amounts. The reduction in total peak discharge is linear and remains constant among the storm events. Tables of these results can be found in Appendix C.

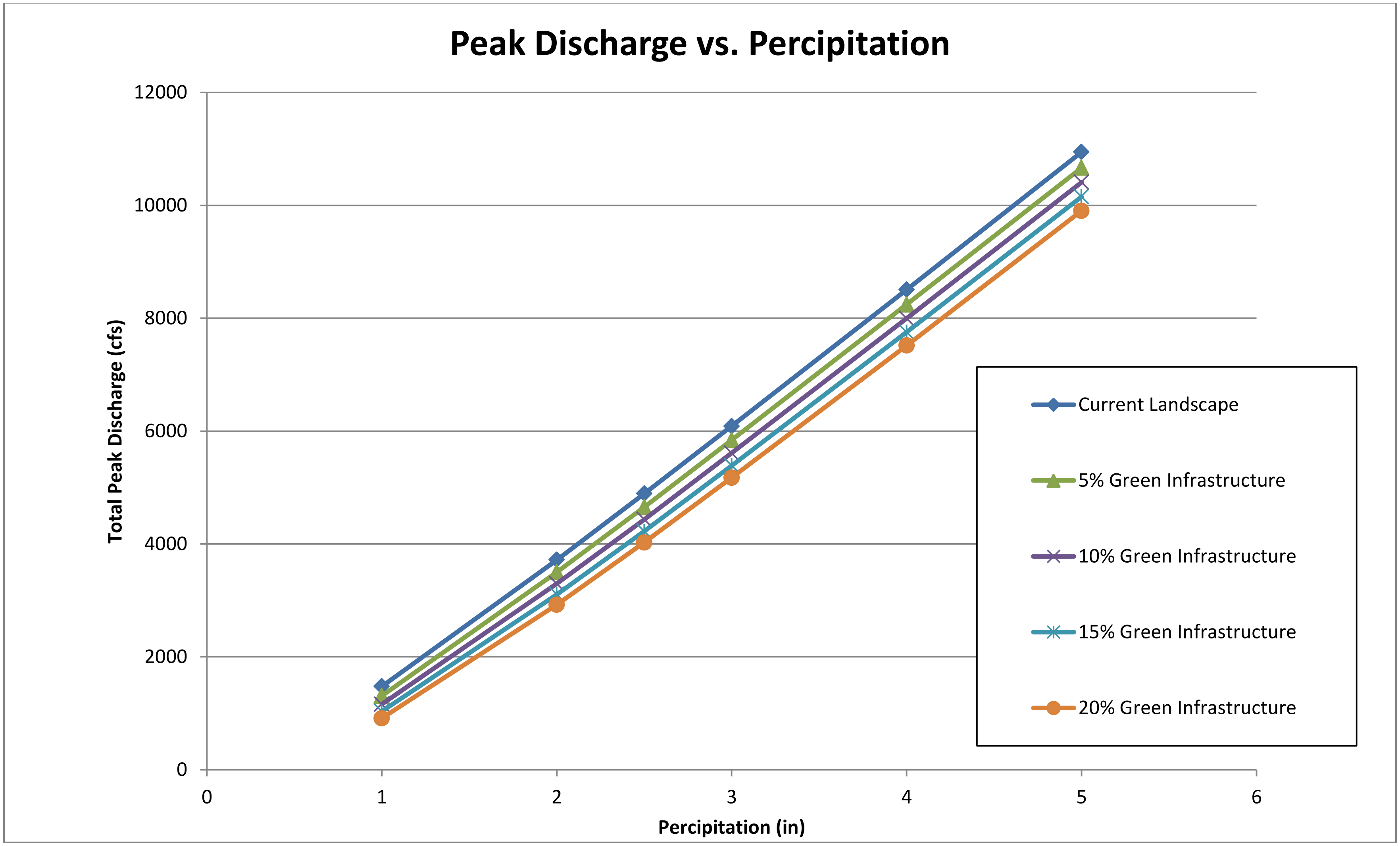


Figure 4: Peak Discharge vs. Precipitation. The peak discharge of each catchment was determined by the TR-55 model. The catchments were summed to obtain a total peak discharge for the study area. Green infrastructure scenarios were implemented into the model that converted a certain percentage of impervious surfaces to pervious ground cover. The results are shown for the current landscape and each green infrastructure scenario for the range of storm events shown in table 5.

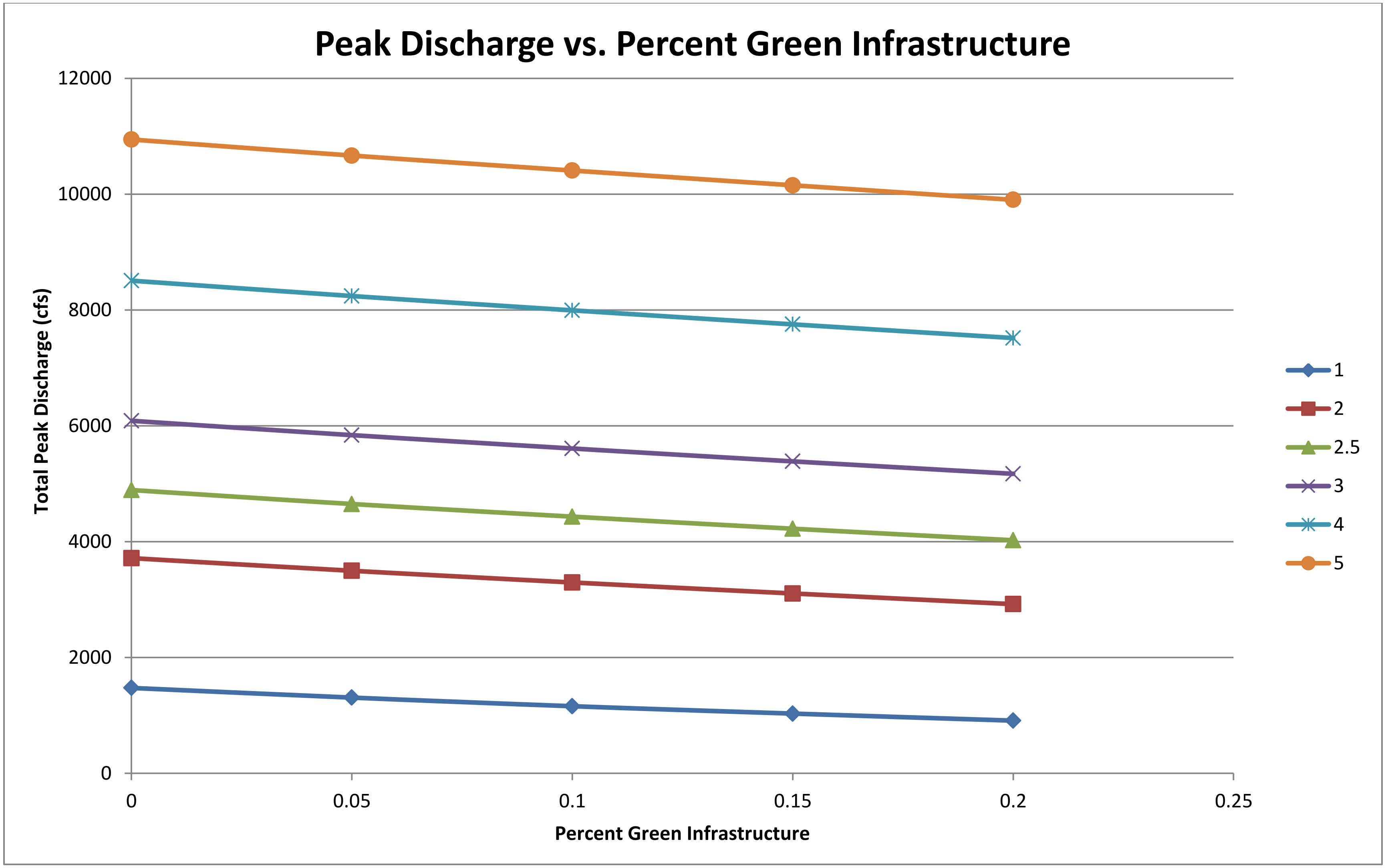


Figure 5: Peak Discharge vs. Percent Green Infrastructure. This figure shows the linear relationship between peak discharge and percent of land surface converted to green infrastructure. The relationship was linear for each storm event. The green infrastructure lowered total peak discharge and a constant rate.

4.2 PERCENT REDUCTION IN PEAK DISCHARGE

Peak discharge is the determining factor in the event of a CSO. The green infrastructure scenarios showed a reduction in total peak discharge of the current landscape for the study area. Having calculated the total peak discharge for the current landscape of the study area, a percent reduction could be easily found. Figure 6 displays a %10 reduction in peak discharge from the current landscaper overlaid with the 5% green infrastructure curve from figure 4. The resulting graph show a relationship between these two values.

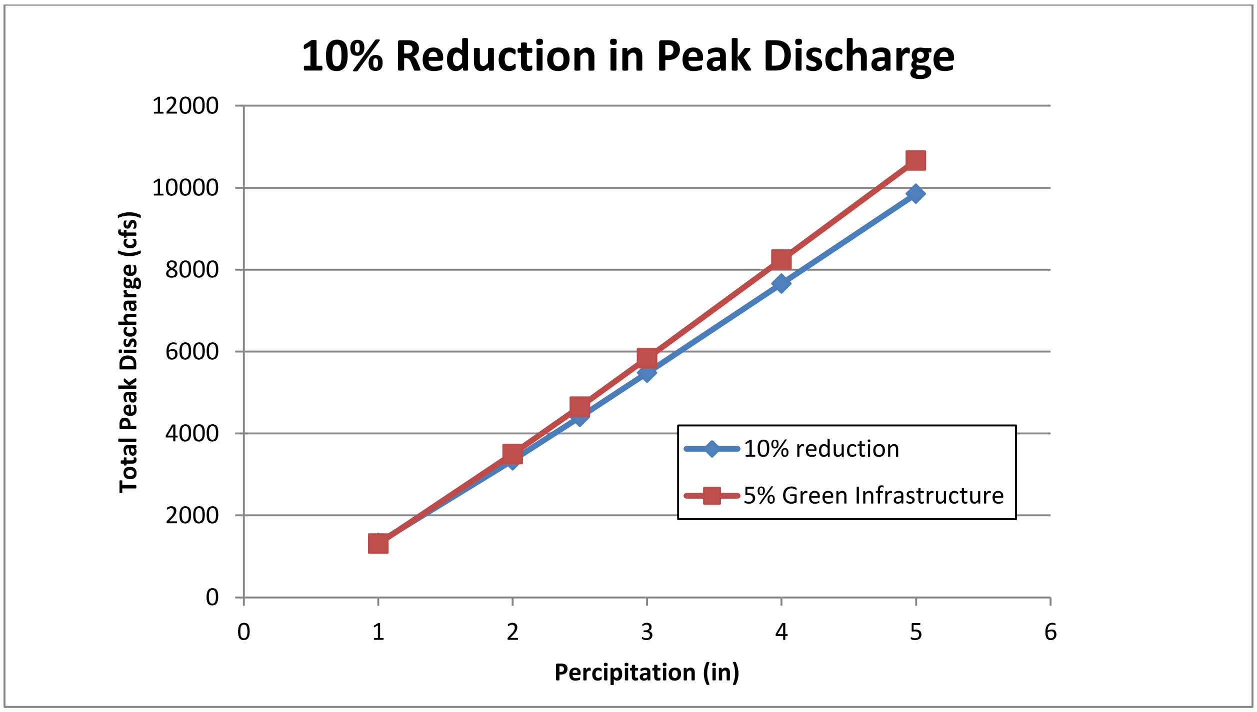


Figure 6: 10% Reduction in Peak Discharge. The 10% reduction of the current landscape was superimposed on the 5% green infrastructure scenario. The curves are very similar for the small storm events. Deviation occurs as precipitation increases. The figure shows that green infrastructure is less effective for large storm events.

By means of the same method, Figure 7 displays a %20 reduction in peak discharge from the current landscaper overlaid with the 10% green infrastructure curve from figure 4. The resulting graph shows a trend similar to that of Figure 6.

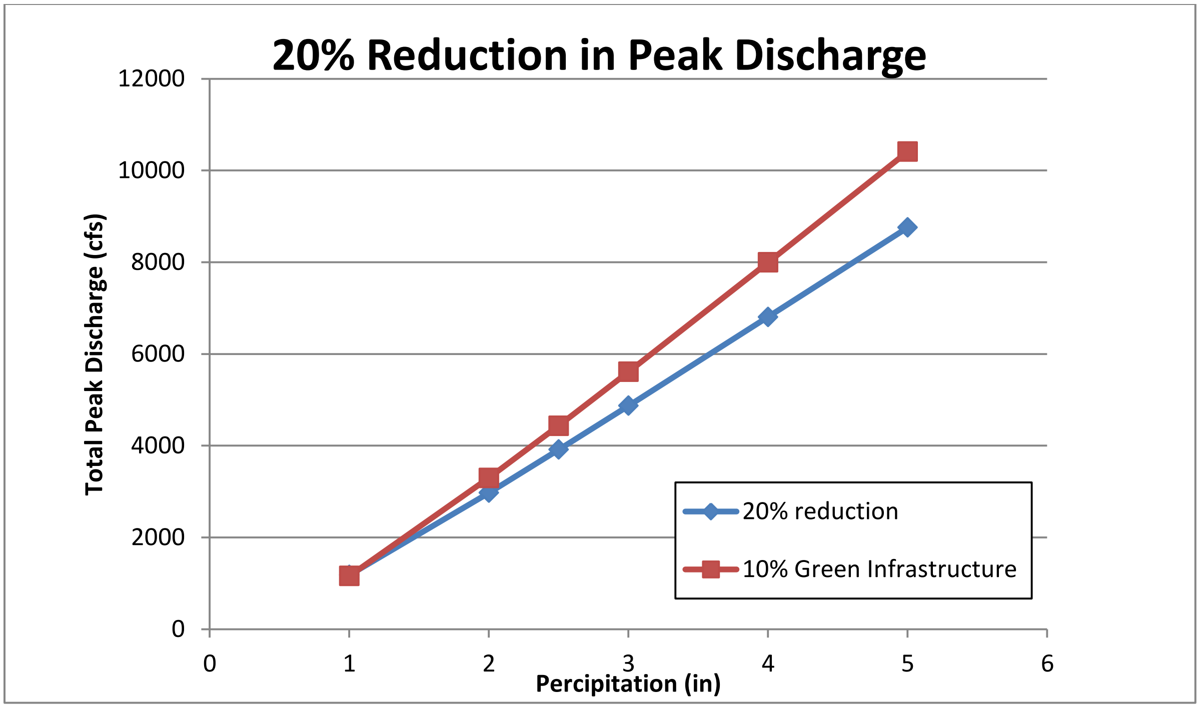


Figure 7: 20% Reduction in Peak Discharge. The 20% reduction of the current landscape was superimposed on the 10% green infrastructure scenario. The curves are very similar for the small storm events, but not as good a fit for the 10% reduction in peak discharge vs. 5% green infrastructure. Deviation occurs as precipitation increases. The figure shows that green infrastructure is less effective for large storm events.

4.3 Total Runoff

The model was run to output the total volume of runoff for the entire study area. The sum of all individual catchments was taken to reach these values. Figure 8 displays the total volume of runoff vs. the precipitation amounts shown in table 5. Five scenarios are shown in figure 4: current landscape, 5, 10, 15, and 20% green infrastructure. The figure displays a linear relationship between the total runoff and the corresponding storm events. Tables of these results can be found in Appendix C.

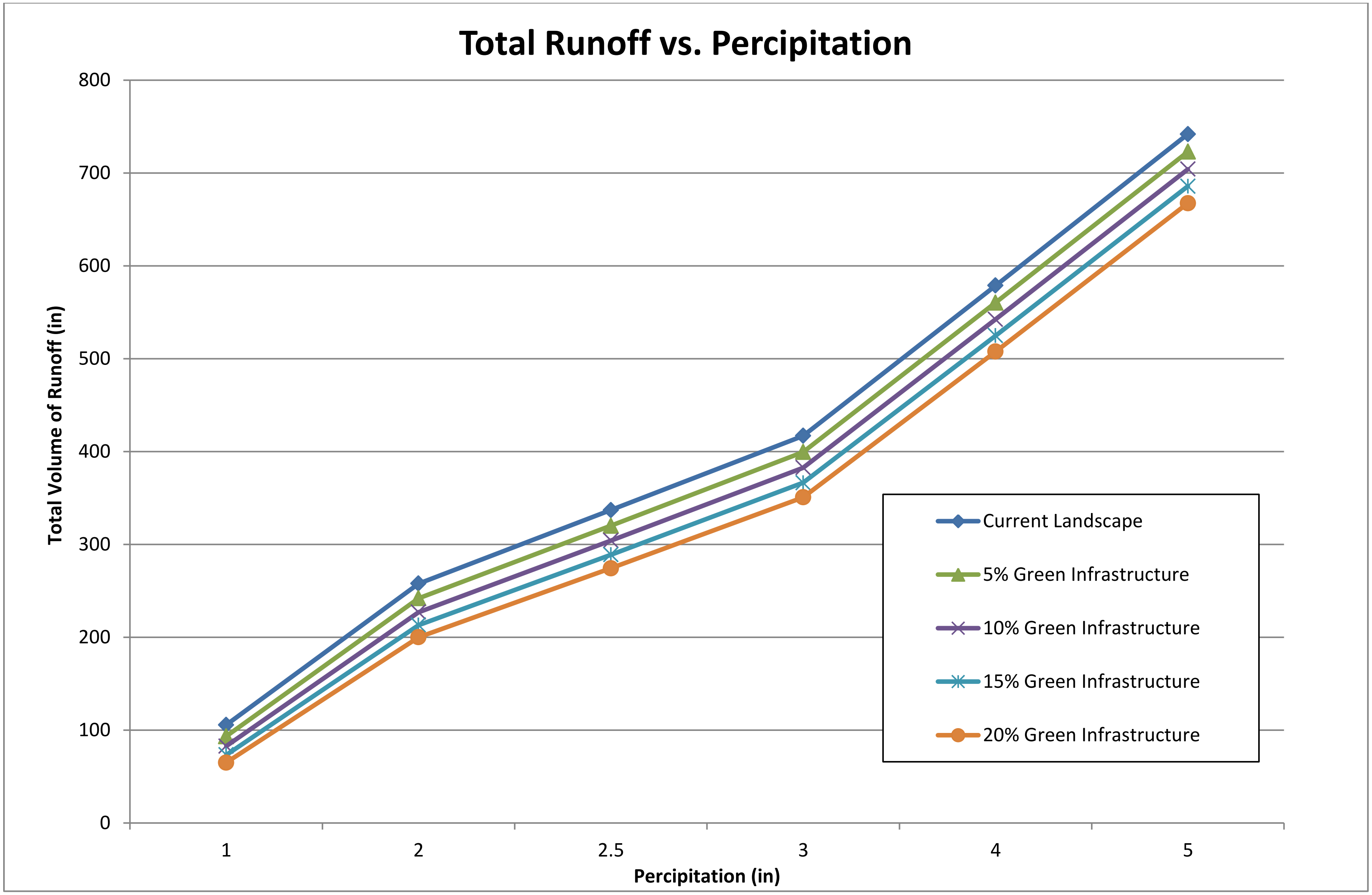


Figure 8: Total Runoff. The total runoff (Q) is calculated from equation 1. Total runoff is not time dependent; it is a function of precipitation and surface type only. The total runoff is proportional to peak discharge, but does not trigger a CSO. Total runoff is decreased by green infrastructure.

CHAPTER 5

5.0 SUMMARY AND CONCLUSION

5.1 Summary of Results

The linear display in figures 4 and 5 can be attributed to the size of the study area and the size of the storm events. The precipitation amounts tested were all very large storm events. The limitations of the TR-55 bound the model to 24-hr storm events. With such a constant flow of precipitation, runoff volumes were large. The large runoff volumes correlated to the linear display of peak discharge. An increase in runoff leads to an increase in peak discharge, as expected. The large study area provided for large values of peak discharge as well. Individual catchments varied in the application of green infrastructure, but summing the study area loses that variation. Individual analysis on a catchment by catchment basis would have been unreasonable for the scope of this research. It was surprising to see the linear relationship between green infrastructure and peak discharge. It was hypothesized that the large storm events would drive infiltration rates to zero over time, and the green infrastructure would lose its effectiveness. The green infrastructure scenarios served to lower the peak discharge at a linear rate independently from the storm amounts as shown in figure 5.

The green infrastructure scenarios were most effective at the lower range of the storm events. This can be shown in figure 6 and 7 as the green infrastructure curves deviate from the percent reduction curves as the precipitation is increased. This is a favorable trend as a majority of storm events measured within the study region fall below 2”. Figure 6 and 7 provides a unique assumption from this research that for every percent increase in green infrastructure within a city, a twofold decrease in peak discharge will be seen. This could prove to be a useful rule of thumb for implementation of green infrastructure.

5.1 Green Infrastructure Practice

An unprecedented development of green infrastructure is currently in the planning stage for New York City (NYC). In his article *New York City Looks to 'Green' Infrastructure to Reduce Combine Sewer Overflows,* Jay Landers describes the draft agreement of the NYC Department of Environmental Protection (DEP) for reducing CSOs. The DEP estimates it will invest $187 million in green infrastructure over the next three years. The DEP expects the green infrastructure to reduce amounts of storm water from entering the city's combined sewer system from 10 percent of available impervious drainage surfaces. This research showed that a 10 percent reduction in impervious surfaces correlated to a 20 percent reduction in peak discharge. This could be a favorable outlook for NYC's environmental engineers. Speaking in response to Mayor Bloomberg's unveiling of the green infrastructure plan in September, the NYC DEP's commissioner Carter Strickland offered this statement: "New York City has been using green infrastructure to improve harbor water quality on a small scale basis. New York Harbor is already cleaner and healthier than it has been in more than a century, but our efforts are not nearly done" (Landers).

5.1 Conclusion

The results of this study have shown that green infrastructure practice can serve to reduce the total volume of runoff for a range of 24hr storm events. The green infrastructure scenarios are a favorable solution for mitigating CSOs but would not be expected to eliminate large quantities of storm runoff on their own. A combined solution of both green and grey infrastructure should be engineered for a sustainable goal of mitigating CSOs.

CHAPTER 6

6.0 WORKS CITED

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APPENDIX A; TABULAR HYDROGRAPH UNIT DISCHARGES FOR TYPE II RAINFALL DISTRIBUTION

Source http://www.cpesc.org/reference/tr55.pdf

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

IA/P = 0.10 — * * * TC = 0.1 HR * * *

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	24	34	53	334	647	1010	623	217	147	123	104	86	76	66	57	51	46	42	38	34	32	29	26	23	21	20	19	18	15	13	12	0
.10	21	29	43	134	267	520	847	701	378	224	157	122	98	75	64	56	50	45	41	36	33	30	27	24	21	20	19	18	16	13	12	0
.20	18	25	35	61	110	215	418	704	702	486	312	209	151	94	73	62	54	49	44	38	34	31	28	25	22	21	19	18	16	14	12	0
.30	17	23	33	56	92	174	337	582	662	545	389	269	190	109	79	65	56	50	45	39	35	32	29	25	22	21	20	18	16	14	12	0
.40	15	20	28	41	51	78	142	272	478	601	563	447	328	172	104	76	63	55	49	42	37	33	29	26	23	21	20	19	17	14	12	0
.50	14	19	26	39	47	68	117	220	392	531	553	482	380	209	121	84	67	57	51	43	38	33	30	27	23	21	20	19	17	14	12	0
.75	12	15	21	29	33	38	49	73	126	224	343	432	464	385	252	156	103	76	62	50	43	36	31	28	25	22	21	19	17	15	12	0
1.0	9	12	15	21	23	26	29	33	40	55	86	148	238	406	434	317	205	130	89	62	50	41	34	30	27	24	22	20	18	16	12	0
1.5	7	8	10	14	15	16	18	20	22	25	29	34	45	101	220	339	373	320	234	131	80	53	40	34	30	27	24	21	19	17	12	2
2.0	4	6	7	9	9	10	11	12	13	15	16	18	20	25	37	72	150	252	336	312	216	109	58	42	34	30	27	24	20	18	13	8
2.5	3	4	5	6	7	7	8	8	9	10	11	12	13	16	19	25	39	75	142	262	308	229	108	58	41	34	30	27	22	19	14	11
3.0	1	2	3	4	4	5	5	6	6	7	7	8	8	10	12	14	17	22	31	76	169	288	236	122	64	43	35	30	24	20	16	11

IA/P = 0.30 — * * * TC = 0.1 HR * * *

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	154	568	936	524	217	172	149	126	107	97	86	76	69	63	58	53	48	46	42	38	34	31	30	28	27	24	20	19	0
.10	0	0	0	19	109	415	762	603	346	230	176	143	119	96	84	74	68	62	57	50	47	44	40	35	32	30	29	27	24	21	19	0
.20	0	0	0	0	13	77	302	609	605	432	297	217	167	115	94	81	73	66	60	53	48	45	41	37	33	31	29	28	25	21	19	0
.30	0	0	0	0	9	54	219	479	563	476	357	263	199	129	99	85	75	68	62	54	49	45	41	37	33	31	29	28	25	21	19	0
.40	0	0	0	0	0	6	38	159	372	500	484	399	309	183	123	96	82	73	66	58	51	46	42	38	34	31	30	28	25	22	19	0
.50	0	0	0	0	0	4	27	115	287	429	465	421	346	213	138	103	86	76	68	59	52	47	43	39	34	32	30	29	25	22	19	0
.75	0	0	0	0	0	0	1	10	46	132	246	338	381	341	243	165	119	94	80	67	58	50	45	41	37	33	31	29	26	23	19	0
1.0	0	0	0	0	0	0	0	1	4	22	69	149	241	357	331	246	170	122	96	76	64	54	47	42	38	34	32	30	27	24	19	0
1.5	0	0	0	0	0	0	0	0	0	0	0	1	4	41	142	258	310	285	224	142	97	71	55	47	43	39	35	32	29	25	20	4
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	49	130	221	279	255	182	108	70	55	47	42	38	34	30	27	20	11
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	52	119	224	256	193	107	70	55	47	42	38	32	28	22	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	52	141	240	199	117	74	56	48	43	35	30	24	18

IA/P = 0.50 — * * * TC = 0.1 HR * * *

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	70	539	377	196	171	154	134	117	108	99	89	83	77	72	67	61	59	56	51	46	43	42	40	38	34	30	28	0
.10	0	0	0	0	47	375	376	256	199	169	146	126	114	102	92	85	79	73	68	62	59	56	52	47	43	42	40	38	34	30	28	0
.20	0	0	0	0	0	31	260	338	283	227	189	160	138	112	99	90	83	77	72	64	60	57	53	48	44	42	41	39	35	30	28	0
.30	0	0	0	0	0	0	21	180	285	284	246	208	176	131	110	97	88	82	76	68	62	59	54	50	45	43	41	39	36	31	28	0
.40	0	0	0	0	0	0	14	125	232	266	253	223	192	142	115	100	91	83	77	69	63	59	55	50	45	43	41	40	36	31	28	0
.50	0	0	0	0	0	0	9	86	183	239	248	231	205	154	122	104	93	85	79	71	64	59	55	51	46	43	41	40	36	32	28	0
.75	0	0	0	0	0	0	3	31	87	147	190	211	213	184	147	121	103	92	84	75	67	61	57	52	47	44	42	40	37	32	28	0
1.0	0	0	0	0	0	0	0	0	1	13	45	92	141	205	197	165	134	112	98	84	75	65	59	55	50	46	43	41	38	34	28	0
1.5	0	0	0	0	0	0	0	0	0	0	0	2	9	51	118	170	183	167	143	111	92	77	65	59	54	50	45	43	39	35	28	2
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	15	51	103	148	168	156	127	96	76	65	58	54	49	45	41	37	29	12
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	31	69	131	159	140	101	78	66	59	54	50	43	39	31	24
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	46	101	151	134	99	77	65	59	54	45	41	33	26

RAINFALL TYPE = II — * * * TC = 0.1 HR * * * — SHEET 1 OF 10

(210-VI-TR-55, Second Ed., June 1986)

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Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

HYDROGRAPH TIME (HOURS)

IA/P = 0.10 — * * * TC = 0.2 HR * * *

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	23	31	47	209	403	739	800	481	250	166	128	102	86	70	61	54	49	44	40	35	33	30	27	24	21	20	19	18	16	13	12	0
.10	19	26	39	86	168	325	601	733	565	355	229	161	122	83	69	59	53	47	43	37	34	31	28	25	22	21	19	18	16	14	12	0
.20	17	23	32	49	74	136	262	488	652	594	435	298	207	115	81	67	58	51	46	40	35	32	29	26	23	21	20	19	16	14	12	0
.30	16	22	30	46	64	112	212	396	566	585	485	360	258	139	90	71	60	53	48	41	36	32	29	26	23	21	20	19	16	14	12	0
.40	14	19	25	37	43	57	94	173	322	485	551	507	409	227	129	87	68	58	52	44	38	33	30	27	24	21	20	19	17	14	12	0
.50	13	18	24	35	40	52	80	142	262	410	504	506	441	269	153	98	73	61	53	45	39	34	30	27	24	22	20	19	17	15	12	0
.75	10	13	17	23	26	30	34	40	55	86	150	247	349	438	360	240	151	101	75	57	47	39	33	29	26	23	21	20	18	15	12	0
1.0	9	11	14	19	21	24	26	30	35	44	62	101	167	337	413	353	245	157	104	68	53	42	35	31	28	24	22	20	18	16	12	0
1.5	6	8	10	13	14	15	17	19	21	23	26	30	37	73	166	288	356	337	264	154	91	57	42	35	30	27	24	22	19	17	13	3
2.0	4	5	7	8	9	10	10	11	12	14	15	16	18	23	31	55	114	206	291	324	239	125	63	44	35	31	28	24	20	18	14	9
2.5	3	4	5	6	6	7	7	8	9	9	10	11	12	15	18	22	32	58	111	227	298	246	122	63	43	35	31	27	22	19	15	11
3.0	1	2	3	4	4	4	5	5	6	6	7	7	8	9	11	13	16	19	27	59	138	280	248	137	70	46	36	31	25	21	16	11

IA/P = 0.30 — * * * TC = 0.2 HR * * *

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	39	180	545	697	497	276	198	158	130	110	93	81	73	67	61	56	49	46	43	39	35	32	30	29	27	24	21	19	0
.10	0	0	0	2	27	129	407	600	532	361	252	190	150	108	90	79	71	65	59	52	48	44	41	36	32	31	29	28	25	21	19	0
.20	0	0	0	2	19	92	302	501	521	415	306	228	176	119	95	82	73	67	61	53	48	45	41	37	33	31	29	28	25	21	19	0
.30	0	0	0	0	1	13	66	223	408	484	438	350	269	163	114	93	80	72	65	57	51	46	42	38	34	31	30	28	25	22	19	0
.40	0	0	0	0	1	9	47	164	327	431	436	379	306	189	127	98	83	74	67	58	52	47	43	38	34	31	30	28	25	22	19	0
.50	0	0	0	0	0	0	6	33	120	258	374	415	391	271	173	121	95	81	72	62	55	48	44	40	35	32	30	29	26	22	19	0
.75	0	0	0	0	0	0	2	13	50	126	221	302	348	323	240	167	121	96	81	68	59	50	45	41	37	33	31	29	26	23	19	0
1.0	0	0	0	0	0	0	0	0	1	6	24	69	139	285	331	280	204	145	109	82	68	56	48	43	39	35	32	30	27	24	19	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	16	79	186	271	288	247	165	110	76	58	49	44	40	35	32	29	26	20	5
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	24	80	163	235	262	202	123	76	58	49	43	39	35	30	27	21	13
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	28	77	179	242	207	120	75	57	48	43	39	32	29	22	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	30	101	207	227	130	80	59	49	44	35	30	24	18

IA/P = 0.50 — * * * TC = 0.2 HR * * *

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	7	98	371	322	221	182	158	137	120	104	94	86	80	74	69	62	60	57	52	47	44	42	40	39	35	30	28	0
.10	0	0	0	0	4	67	270	305	249	204	174	149	130	108	97	88	82	76	71	64	60	57	53	48	44	42	41	39	35	30	28	0
.20	0	0	0	0	0	3	45	195	268	255	221	189	163	125	106	95	87	80	75	67	62	58	54	49	45	43	41	39	35	31	28	0
.30	0	0	0	0	0	2	31	140	226	245	229	203	176	134	111	98	89	82	76	68	62	59	55	50	45	43	41	39	36	31	28	0
.40	0	0	0	0	0	1	21	101	184	225	228	211	188	144	117	101	91	84	78	69	63	59	55	50	45	43	41	40	36	31	28	0
.50	0	0	0	0	0	0	1	14	72	146	199	218	213	175	137	113	99	89	82	73	66	60	56	52	47	43	42	40	36	32	28	0
.75	0	0	0	0	0	0	0	5	28	71	121	162	186	193	161	133	112	98	88	78	70	62	57	53	48	44	42	41	37	33	28	0
1.0	0	0	0	0	0	0	0	0	0	2	13	38	77	154	186	174	147	122	105	89	78	68	60	56	51	46	43	42	38	34	28	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	2	22	71	129	163	168	150	120	98	80	67	60	55	51	46	43	40	36	28	4
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	25	65	112	146	157	134	103	79	67	60	55	50	46	41	38	29	14
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	26	60	117	148	136	101	79	66	59	54	50	43	39	31	24
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	40	90	142	130	99	78	66	59	54	45	41	33	26

RAINFALL TYPE = II — * * * TC = 0.2 HR * * * — SHEET 2 OF 10

5–30

(210-VI-TR-55, Second Ed., June 1986)

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC = 0.3 HR * * *														IA/P = 0.10				
0.0	20	28	41	118	235	447	676	676	459	283	196	146	114	80	66	57	51	46	42	37	33	31	28	24	22	20	19	18	16	13	12	0
.10	19	26	39	99	189	361	571	641	520	362	251	181	136	89	70	60	53	48	43	37	34	31	28	25	22	21	19	18	16	14	12	0
.20	17	23	32	53	83	154	292	478	587	542	422	308	223	127	86	68	58	52	46	40	35	32	29	26	23	21	20	19	16	14	12	0
.30	16	22	30	49	72	127	237	398	524	536	460	359	268	151	97	73	61	53	48	41	36	32	29	26	23	21	20	19	16	14	12	0
.40	14	19	25	37	45	63	105	193	330	459	510	477	398	237	139	92	70	59	52	44	38	34	30	27	24	21	20	19	17	14	12	0
.50	13	18	24	35	42	56	89	158	272	397	472	475	424	274	163	104	76	62	54	46	39	34	30	27	24	22	20	19	17	15	12	0
.75	11	14	19	26	30	34	42	59	95	160	250	339	417	398	299	196	128	89	69	54	45	37	32	29	26	23	21	20	17	15	12	0
1.0	9	11	14	19	21	24	27	30	36	46	68	109	174	328	396	346	248	163	109	70	54	43	35	31	28	24	22	20	18	16	12	0
1.5	6	8	10	13	14	15	17	19	21	23	26	31	38	77	169	282	347	330	264	158	94	58	42	35	31	27	24	22	19	17	13	3
2.0	4	5	7	8	9	10	10	11	12	14	15	16	18	23	32	57	116	205	285	317	239	128	64	44	36	31	28	25	20	18	14	9
2.5	2	4	5	6	6	7	7	8	9	9	10	11	12	15	18	23	33	60	113	223	293	245	125	65	44	35	31	27	22	19	15	11
3.0	1	2	3	4	4	4	5	5	6	6	7	7	8	9	11	13	16	20	27	61	138	275	246	139	72	46	36	31	25	21	16	11
IA/P = 0.30														* * * TC = 0.3 HR * * *														IA/P = 0.30				
0.0	0	0	0	11	64	251	525	574	454	303	221	173	140	104	88	77	70	64	58	51	47	44	40	36	32	31	29	28	24	21	19	0
.10	0	0	0	0	7	45	183	411	520	476	360	268	205	133	101	85	76	69	62	55	49	45	41	37	33	31	30	28	25	21	19	0
.20	0	0	0	0	5	32	132	318	452	468	396	310	240	151	109	90	78	70	64	56	50	46	42	38	33	31	30	28	25	22	19	0
.30	0	0	0	0	0	3	22	96	244	383	440	411	344	217	142	105	87	76	69	60	53	47	43	39	35	32	30	29	26	22	19	0
.40	0	0	0	0	0	2	16	69	186	317	399	407	365	246	160	115	92	79	71	61	54	48	43	39	35	32	30	29	26	22	19	0
.50	0	0	0	0	0	0	2	11	50	140	258	352	389	327	223	149	110	89	77	66	57	50	45	41	36	33	31	29	26	23	19	0
.75	0	0	0	0	0	0	1	4	20	63	135	219	290	335	281	205	146	110	89	72	62	52	46	42	38	34	31	30	27	23	19	0
1.0	0	0	0	0	0	0	0	0	0	2	9	32	78	216	320	306	243	176	128	90	72	59	49	44	40	36	33	31	28	24	19	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	2	20	84	185	264	281	246	168	112	77	58	49	44	40	36	32	29	26	20	5
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	50	121	200	257	224	141	83	61	50	44	40	36	31	28	21	14
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	51	145	239	223	137	82	60	50	44	40	33	29	22	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	19	74	184	224	146	89	63	51	45	36	31	24	18
IA/P = 0.50														* * * TC = 0.3 HR * * *														IA/P = 0.50				
0.0	0	0	0	0	1	25	151	299	277	219	187	162	141	113	100	90	84	78	72	65	61	58	53	48	44	42	41	39	35	31	28	0
.10	0	0	0	0	1	17	106	235	263	234	202	175	152	120	104	93	85	79	73	66	61	58	54	49	44	42	41	39	35	31	28	0
.20	0	0	0	0	0	0	12	75	182	236	234	213	188	144	116	101	91	84	78	70	63	59	55	50	45	43	41	40	36	31	28	0
.30	0	0	0	0	0	0	8	52	138	203	224	217	197	154	123	105	94	86	79	71	64	59	55	51	46	43	42	40	36	32	28	0
.40	0	0	0	0	0	0	5	37	105	170	206	213	203	164	131	110	97	88	81	72	65	60	56	51	46	43	42	40	36	32	28	0
.50	0	0	0	0	0	0	0	4	26	78	140	184	203	191	155	126	107	95	86	76	69	62	57	53	48	44	42	41	37	33	28	0
.75	0	0	0	0	0	0	0	1	10	34	73	117	153	184	173	146	122	105	94	82	73	64	58	54	49	45	43	41	37	33	28	0
1.0	0	0	0	0	0	0	0	0	0	0	4	17	42	114	168	178	159	134	114	94	82	70	61	57	52	47	44	42	39	35	28	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	10	44	98	144	163	157	130	105	84	69	61	56	52	47	44	40	36	29	6
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	44	87	127	153	141	110	83	69	61	56	51	47	42	38	30	17
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	16	42	97	138	145	107	82	68	60	55	51	43	40	32	25
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	27	71	127	139	105	81	68	60	55	46	41	33	27

RAINFALL TYPE = II * * * TC = 0.3 HR * * * SHEET 3 OF 10

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC = 0.4 HR * * *														IA/P = 0.10				
0.0	18	25	36	77	141	271	468	592	574	431	298	216	163	104	77	63	55	49	44	38	34	31	28	25	22	21	20	18	16	14	12	0
.10	18	24	34	67	116	219	385	523	557	473	357	263	196	119	84	67	57	51	46	39	35	32	29	25	22	21	20	19	16	14	12	0
.20	15	20	28	44	59	97	179	316	454	523	489	401	309	178	112	81	65	56	49	42	37	33	30	26	23	21	20	19	17	14	12	0
.30	15	20	27	41	53	82	147	260	389	478	486	429	349	210	129	89	69	58	51	43	38	33	30	27	24	21	20	19	17	14	12	0
.40	13	17	23	33	38	48	71	121	214	331	429	467	442	308	189	120	85	66	56	47	41	35	31	28	24	22	20	19	17	15	12	0
.50	12	16	22	31	36	44	62	102	176	279	379	438	440	339	218	137	94	71	59	49	42	35	31	28	25	22	21	19	17	15	12	0
.75	10	13	17	24	26	30	35	45	65	106	170	251	326	393	341	245	164	112	81	59	48	39	33	30	26	23	21	20	18	15	12	0
1.0	8	10	13	17	19	21	24	27	31	37	50	75	118	251	360	376	292	205	138	83	60	45	36	32	28	25	22	21	18	16	12	1
1.5	6	7	9	12	13	14	15	17	19	21	23	26	31	56	121	224	311	333	293	192	115	66	45	36	31	28	25	22	19	17	13	4
2.0	4	5	6	8	8	9	10	10	11	12	14	15	16	20	27	43	85	159	243	306	264	154	74	47	37	32	28	25	21	18	14	9
2.5	2	3	4	5	6	6	7	7	8	9	9	10	11	13	16	20	27	46	85	184	285	262	147	74	47	37	32	28	22	19	15	11
3.0	1	2	2	3	4	4	4	5	5	6	6	7	7	8	10	12	14	17	23	47	109	227	268	160	83	50	38	32	25	21	16	11
IA/P = 0.30														* * * TC = 0.4 HR * * *														IA/P = 0.30				
0.0	0	0	0	4	26	113	296	480	495	413	306	234	186	127	100	84	74	67	61	54	49	45	41	37	33	31	29	28	25	21	19	0
.10	0	0	0	0	2	18	81	224	395	462	430	347	272	172	121	96	82	73	66	57	51	46	42	38	34	31	30	28	25	22	19	0
.20	0	0	0	0	2	13	59	169	320	414	424	373	305	196	134	103	85	75	67	59	52	47	43	39	34	32	30	29	25	22	19	0
.30	0	0	0	0	0	1	9	42	127	255	361	403	383	274	181	127	99	83	73	63	55	48	44	40	36	32	30	29	26	23	19	0
.40	0	0	0	0	0	1	6	30	94	202	308	372	379	298	203	141	106	87	76	65	56	49	44	40	36	32	31	29	26	23	19	0
.50	0	0	0	0	0	0	0	4	21	70	158	258	334	364	270	187	133	102	85	70	60	51	46	41	37	33	31	30	26	23	19	0
.75	0	0	0	0	0	0	0	2	8	30	76	145	219	321	305	241	177	130	102	78	65	55	47	43	38	34	32	30	27	24	19	0
1.0	0	0	0	0	0	0	0	0	0	1	4	15	42	150	267	308	272	209	154	103	79	62	51	45	41	37	33	31	28	25	19	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	10	51	136	226	274	263	195	131	85	62	51	45	41	36	33	29	26	20	6
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	31	86	162	252	239	162	93	64	52	45	41	37	31	28	21	15
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	33	112	202	235	155	92	64	52	45	41	33	29	23	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	21	76	182	221	148	90	63	51	45	36	31	24	18
IA/P = 0.50														* * * TC = 0.4 HR * * *														IA/P = 0.50				
0.0	0	0	0	0	0	7	59	168	245	257	213	186	163	128	109	96	88	81	75	67	62	58	54	50	45	43	41	39	35	31	28	0
.10	0	0	0	0	0	0	5	41	125	205	240	222	198	154	123	106	94	86	79	71	64	60	56	51	46	43	42	40	36	32	28	0
.20	0	0	0	0	0	0	3	28	93	168	216	220	205	164	131	110	97	88	81	72	65	60	56	51	46	43	42	40	36	32	28	0
.30	0	0	0	0	0	0	0	2	20	69	135	189	209	192	155	126	107	95	86	77	69	62	57	53	48	44	42	41	37	33	28	0
.40	0	0	0	0	0	0	0	1	14	50	106	161	193	202	163	133	112	98	89	78	70	62	58	53	48	44	42	41	37	33	28	0
.50	0	0	0	0	0	0	0	1	9	37	83	135	174	194	171	140	117	102	91	80	71	63	58	54	49	45	43	41	37	33	28	0
.75	0	0	0	0	0	0	0	0	0	3	15	40	76	147	177	169	146	124	107	90	79	68	60	56	51	47	43	42	38	34	28	0
1.0	0	0	0	0	0	0	0	0	0	0	1	7	21	78	141	173	167	146	125	101	86	73	63	58	53	48	45	42	39	35	28	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	26	71	121	153	159	139	113	89	72	63	57	53	48	44	40	37	29	7
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	45	86	138	150	125	93	74	64	58	53	48	42	39	31	20
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	17	59	112	143	121	91	73	63	57	53	45	40	32	26
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	11	40	101	138	117	90	73	63	57	48	42	34	27

RAINFALL TYPE = II * * * TC = 0.4 HR * * * SHEET 4 OF 10

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10															* * * TC = 0.5 HR * * *														IA/P = 0.10			
0.0	17	23	32	57	94	170	308	467	529	507	402	297	226	140	96	74	61	53	47	41	36	32	29	26	23	21	20	19	16	14	12	0
.10	16	22	30	51	80	140	252	395	484	499	434	343	265	162	108	80	65	55	49	42	36	33	29	26	23	21	20	19	16	14	12	0
.20	14	19	25	38	47	69	116	207	332	434	477	449	378	238	149	101	77	62	53	45	39	34	30	27	24	22	20	19	17	14	12	0
.30	13	18	24	35	43	60	97	170	278	382	446	448	401	270	171	114	83	66	56	46	40	34	31	27	24	22	20	19	17	15	12	0
.40	12	15	21	29	33	40	53	83	141	233	332	408	434	361	243	157	107	79	64	51	43	36	32	28	25	22	21	20	17	15	12	0
.50	11	15	20	28	31	37	48	71	118	194	286	367	412	378	271	178	119	86	68	53	44	37	32	29	25	23	21	20	17	15	12	0
.75	9	11	14	19	21	24	27	31	37	49	74	118	182	319	374	328	244	169	117	76	56	43	35	31	28	25	22	21	18	16	12	1
1.0	7	9	12	16	17	19	21	24	27	32	40	55	83	188	309	359	322	245	172	102	68	49	38	32	29	26	23	21	19	16	12	1
1.5	5	7	8	11	12	13	14	15	17	19	21	23	27	43	89	175	269	322	309	225	140	77	49	38	32	29	25	23	20	17	13	5
2.0	3	4	6	7	8	8	9	10	10	11	12	14	15	18	23	35	65	123	202	297	280	181	88	52	39	33	29	26	21	19	14	10
2.5	2	3	4	5	5	6	6	7	7	8	9	9	10	12	15	18	24	36	66	150	244	278	171	87	52	39	33	29	23	20	15	11
3.0	1	1	2	3	3	4	4	4	5	5	6	6	7	8	9	11	13	16	20	37	86	198	263	182	96	56	40	33	26	21	16	11
IA/P = 0.30															* * * TC = 0.5 HR * * *														IA/P = 0.30			
0.0	0	0	0	1	9	53	157	314	433	439	379	299	237	159	118	95	81	71	65	56	50	46	42	38	34	31	30	28	25	22	19	0
.10	0	0	0	0	1	6	37	117	248	372	416	391	330	218	150	113	92	79	70	60	53	47	43	39	35	32	30	29	26	22	19	0
.20	0	0	0	0	1	4	26	87	194	313	382	388	349	244	167	122	97	82	72	62	54	48	43	39	35	32	30	29	26	22	19	0
.30	0	0	0	0	0	0	3	19	64	151	259	341	372	316	223	156	117	94	80	67	58	50	45	41	36	33	31	29	26	23	19	0
.40	0	0	0	0	0	0	2	13	47	116	211	298	354	328	245	172	127	100	83	69	59	51	45	41	37	33	31	29	26	23	19	0
.50	0	0	0	0	0	0	0	1	9	34	89	170	255	341	303	225	161	120	96	76	64	54	47	42	38	34	31	30	27	24	19	0
.75	0	0	0	0	0	0	0	1	4	14	41	89	152	270	305	268	207	155	118	87	70	57	48	44	39	35	32	30	27	24	19	0
1.0	0	0	0	0	0	0	0	0	0	0	2	7	22	98	212	295	285	237	181	120	88	67	53	46	42	38	34	31	28	25	19	2
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	30	95	183	249	265	217	152	96	66	53	46	41	37	34	30	26	20	8
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	18	59	125	221	245	182	105	69	54	47	42	38	32	28	22	16
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	21	84	174	230	172	103	69	54	46	42	34	30	23	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	56	157	217	163	101	68	53	46	37	31	25	18
IA/P = 0.50															* * * TC = 0.5 HR * * *														IA/P = 0.50			
0.0	0	0	0	0	0	2	26	89	170	217	229	200	179	144	119	104	93	85	78	70	64	59	55	51	46	43	41	40	36	32	28	0
.10	0	0	0	0	0	0	1	18	65	135	190	216	205	170	137	115	101	91	83	74	67	61	56	52	47	44	42	40	36	32	28	0
.20	0	0	0	0	0	0	1	12	47	106	162	198	203	178	145	121	105	94	85	76	68	61	57	52	48	44	42	40	37	32	28	0
.30	0	0	0	0	0	0	0	1	8	34	82	135	177	194	168	139	117	102	92	80	71	63	58	54	49	45	43	41	37	33	28	0
.40	0	0	0	0	0	0	0	0	6	25	63	111	155	189	174	146	122	106	94	82	73	64	58	54	50	45	43	41	37	33	28	0
.50	0	0	0	0	0	0	0	0	4	18	48	90	133	184	177	152	128	110	97	84	74	65	59	55	50	45	43	41	38	33	28	0
.75	0	0	0	0	0	0	0	0	1	7	22	47	80	142	169	164	144	124	108	91	79	68	61	56	51	47	44	42	38	34	28	0
1.0	0	0	0	0	0	0	0	0	0	0	1	3	11	51	112	155	166	154	134	109	91	76	65	59	54	49	45	43	39	35	28	2
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	16	50	97	136	154	145	121	95	75	64	58	54	49	45	41	37	29	10
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	18	47	86	134	146	125	94	75	64	58	53	49	42	39	31	21
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	44	95	140	127	97	77	65	58	54	45	41	33	26
3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	29	86	135	122	95	76	65	58	49	43	35	27
RAINFALL TYPE = II															* * * TC = 0.5 HR * * *														SHEET 5 OF 10			

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10															* * * TC = 0.75 HR * * *														IA/P = 0.10			
0.0	13	18	24	36	46	68	115	194	294	380	424	410	369	252	172	123	93	74	61	49	41	35	31	27	24	22	20	19	17	15	12	0
.10	13	17	23	34	42	59	97	162	250	337	395	405	381	279	191	135	100	79	65	51	42	36	31	28	25	22	21	19	17	15	12	0
.20	11	15	20	28	32	39	52	82	135	211	295	362	391	351	255	178	127	95	75	57	46	38	32	29	26	23	21	20	17	15	12	0
.30	11	14	19	26	30	36	47	70	113	179	256	326	379	360	277	196	140	103	80	60	48	38	33	29	26	23	21	20	18	15	12	0
.40	10	12	16	22	25	28	33	42	61	96	151	221	291	367	336	255	182	131	98	69	54	42	34	30	27	24	22	20	18	16	12	0
.50	9	12	16	21	24	27	31	39	53	82	128	190	258	358	343	274	200	144	106	74	56	43	35	30	27	24	22	20	18	16	12	0
.75	8	10	13	17	18	21	23	26	31	39	55	82	122	230	314	329	281	217	161	104	72	51	38	33	29	26	23	21	19	16	12	1
1.0	6	8	10	13	14	15	17	19	21	23	27	32	42	89	177	272	319	303	249	163	105	66	45	36	31	27	24	22	19	17	13	3
1.5	4	6	7	9	10	10	11	12	14	15	16	18	20	27	46	90	163	241	295	275	204	119	66	45	35	31	27	24	20	18	13	7
2.0	3	4	5	6	7	7	8	9	9	10	11	12	13	16	20	28	48	89	151	245	274	213	115	65	44	35	30	27	22	19	14	10
2.5	1	2	3	4	4	5	5	6	6	7	7	8	8	10	12	14	17	24	37	86	170	260	219	127	71	47	36	31	24	20	16	11
3.0	1	1	2	3	3	3	4	4	4	5	5	5	6	7	8	10	11	14	17	30	64	157	247	205	122	70	46	36	27	22	17	12
IA/P = 0.30															* * * TC = 0.75 HR * * *														IA/P = 0.30			
0.0	0	0	0	0	1	6	30	86	174	266	326	348	328	246	181	138	110	92	79	66	57	49	44	40	36	32	31	29	26	23	19	0
.10	0	0	0	0	0	1	4	22	65	137	223	292	329	303	228	170	131	106	89	73	61	52	46	41	37	33	31	29	26	23	19	0
.20	0	0	0	0	0	0	3	15	48	108	185	256	305	321	245	184	141	112	93	75	63	53	46	42	37	34	31	30	27	23	19	0
.30	0	0	0	0	0	0	2	11	36	84	151	221	277	308	260	199	152	120	98	78	65	54	47	42	38	34	31	30	27	23	19	0
.40	0	0	0	0	0	0	0	1	8	27	65	122	188	286	301	243	187	144	114	87	71	57	48	43	39	35	32	30	27	24	19	1
.50	0	0	0	0	0	0	0	1	6	20	50	98	158	263	292	254	200	155	122	91	74	59	49	44	40	35	32	30	27	24	19	1
.75	0	0	0	0	0	0	0	0	0	2	8	23	51	140	231	269	253	211	167	119	90	68	53	46	42	37	34	31	28	25	19	2
1.0	0	0	0	0	0	0	0	0	0	0	0	1	4	29	96	186	249	261	231	169	120	84	61	50	44	40	36	33	29	26	20	5
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	34	91	163	220	241	197	131	83	61	50	44	40	35	31	27	21	12
2.0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	2	11	36	85	174	226	200	127	82	60	49	44	39	32	29	22	17
2.5	o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	37	105	196	214	135	87	62	51	44	36	31	24	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	24	96	205	189	130	85	62	50	39	32	26	18
IA/P = 0.50															* * * TC = 0.75 HR * * *														IA/P = 0.50			
0.0	0	0	0	0	0	0	2	16	45	92	137	166	185	170	146	125	110	98	89	79	70	63	58	53	48	44	42	41	37	33	28	0
.10	0	0	0	0	0	0	0	1	11	34	73	115	149	180	163	141	122	107	96	84	74	65	59	54	50	45	43	41	38	33	28	0
.20	0	0	0	0	0	0	0	1	8	25	57	96	131	173	166	146	126	111	99	86	76	66	59	55	50	46	43	41	38	34	28	0
.30	0	0	0	0	0	0	0	0	1	5	18	44	79	143	170	160	141	122	108	92	81	69	61	56	52	47	44	42	38	34	28	1
.40	0	0	0	0	0	0	0	0	0	4	14	34	64	127	166	162	145	127	111	95	82	70	62	57	52	47	44	42	38	34	28	1
.50	0	0	0	0	0	0	0	0	0	0	2	10	26	82	138	162	157	140	123	103	88	75	64	58	53	49	45	43	39	35	28	2
.75	0	0	0	0	0	0	0	0	0	0	1	4	12	47	98	139	154	148	135	113	96	80	67	60	55	50	46	43	39	36	29	3
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	30	73	119	146	151	134	113	91	74	63	58	53	48	45	41	37	29	7
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	30	66	105	143	143	117	90	73	63	57	52	48	42	39	30	18
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	30	77	121	137	114	88	72	63	57	52	44	40	32	25
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	19	55	111	132	111	87	71	62	56	47	42	34	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	51	112	128	108	86	71	62	51	44	36	27
RAINFALL TYPE = II															* * * TC = 0.75 HR * * *														SHEET 6 OF 10			

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL TIME (hr) / HYDROGRAPH TIME (HOURS)

IA/P = 0.10 * * * TC = 1.0 HR * * * IA/P = 0.10

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	11	15	20	29	35	47	72	112	168	231	289	329	357	313	239	175	133	103	83	63	50	40	33	29	26	23	21	20	17	15	12	0
.10	10	13	17	24	27	33	42	62	95	144	202	260	306	340	293	222	165	126	98	72	56	43	35	30	27	24	22	20	18	15	12	0
.20	10	13	17	23	26	30	38	54	82	123	176	232	281	332	303	238	179	136	105	76	59	45	35	30	27	24	22	20	18	16	12	1
.30	9	12	16	22	24	28	35	48	70	105	152	205	256	323	310	254	193	146	113	81	61	46	36	31	27	24	22	20	18	16	12	1
.40	8	11	14	19	21	23	27	32	42	61	91	132	181	276	318	294	237	181	138	95	70	51	39	32	28	25	23	21	18	16	12	1
.50	8	10	13	18	20	22	25	30	38	53	78	114	159	253	311	300	251	195	149	102	74	53	40	33	29	25	23	21	18	16	12	1
.75	7	8	11	14	16	17	19	21	25	30	38	53	76	146	228	284	293	256	208	143	99	66	46	36	31	27	24	22	19	17	13	2
1.0	5	7	8	11	12	13	14	16	17	19	22	25	31	57	111	188	256	286	272	208	144	90	56	41	33	29	26	23	20	17	13	4
1.5	4	5	6	8	8	9	10	11	12	13	14	15	17	22	33	59	107	171	231	268	235	157	88	56	41	33	29	25	21	18	14	8
2.0	2	3	4	5	5	6	6	7	7	8	9	9	10	12	15	19	27	44	78	157	231	252	167	96	59	42	34	29	23	20	15	11
2.5	1	2	2	3	4	4	4	5	5	6	6	7	7	8	10	12	15	19	27	58	120	214	241	159	94	59	42	34	26	21	16	11
3.0	0	1	1	2	2	3	3	3	4	4	4	5	5	6	7	8	10	12	14	22	44	113	214	231	152	91	58	42	29	23	17	12

IA/P = 0.30 * * * TC = 1.0 HR * * * IA/P = 0.30

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	1	4	16	42	83	137	195	243	271	292	227	178	143	117	98	79	66	55	47	42	38	34	31	30	27	23	19	0
.10	0	0	0	0	0	0	3	12	32	66	113	168	218	279	260	213	169	136	113	88	72	59	49	43	39	35	32	30	27	24	19	1
.20	0	0	0	0	0	0	2	9	24	52	93	143	193	271	271	225	180	145	119	92	75	60	50	44	39	35	32	30	27	24	19	1
.30	0	0	0	0	0	0	1	6	18	41	75	120	169	246	264	234	191	153	125	96	78	62	51	44	40	36	33	31	27	24	19	1
.40	0	0	0	0	0	0	0	1	4	14	32	61	100	190	251	259	222	181	146	109	86	67	53	46	41	37	33	31	28	25	19	2
.50	0	0	0	0	0	0	0	1	3	10	24	49	83	168	237	254	230	191	155	115	90	69	54	47	42	37	34	31	28	25	19	2
.75	0	0	0	0	0	0	0	0	0	1	4	12	25	76	150	213	239	228	198	149	112	82	61	50	44	39	35	32	29	26	20	4
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	15	51	113	182	226	234	197	150	104	72	56	47	42	38	34	30	27	20	7
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	18	51	104	162	220	210	158	102	71	56	47	42	37	31	28	22	13
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	20	49	121	187	209	152	100	70	55	47	41	34	29	23	17
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	32	87	171	199	146	98	69	54	46	37	31	24	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	62	158	192	151	103	73	56	41	34	26	18

IA/P = 0.50 * * * TC = 1.0 HR * * * IA/P = 0.50

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	0	0	1	7	21	42	71	101	126	160	154	138	123	110	100	87	77	67	60	55	50	46	43	41	38	34	28	1
.10	0	0	0	0	0	0	0	1	5	15	33	58	87	134	156	149	134	120	108	93	82	71	62	57	52	47	44	42	38	34	28	1
.20	0	0	0	0	0	0	0	1	4	12	26	48	74	123	153	153	137	123	111	95	84	72	63	57	52	47	44	42	38	34	28	1
.30	0	0	0	0	0	0	0	0	3	9	20	38	62	111	143	150	140	127	114	98	86	73	63	58	53	48	45	42	39	35	28	1
.40	0	0	0	0	0	0	0	0	0	2	6	16	31	75	120	145	148	137	123	106	91	77	66	59	54	49	45	43	39	35	29	2
.50	0	0	0	0	0	0	0	0	0	1	5	12	25	64	109	139	146	139	127	108	94	79	67	60	55	50	46	43	39	36	29	3
.75	0	0	0	0	0	0	0	0	0	0	2	5	12	39	78	115	136	140	134	117	101	84	70	62	56	51	47	44	40	36	29	4
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	26	59	96	125	139	133	117	97	78	66	59	54	49	46	41	37	29	8
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	26	54	86	123	133	119	95	77	66	59	54	49	43	39	31	17
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	25	64	104	129	116	93	76	65	58	53	45	41	33	24
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	34	84	125	117	96	78	66	59	49	43	35	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	32	89	122	114	94	77	66	53	45	37	27

RAINFALL TYPE = II * * * TC = 1.0 HR * * * SHEET 7 OF 10

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution —continued

TRVL TIME (hr) / HYDROGRAPH TIME (HOURS)

IA/P = 0.10 * * * TC = 1.25 HR * * * IA/P = 0.10

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	10	13	18	25	29	38	54	81	118	163	213	256	284	311	266	212	163	129	104	78	61	47	37	31	27	24	22	20	18	16	12	1
.10	10	13	17	23	27	34	47	69	102	143	189	234	267	297	274	226	175	138	111	82	64	48	38	31	27	24	22	20	18	16	12	1
.20	9	11	15	20	22	26	31	42	60	88	124	168	212	280	292	261	212	166	131	95	72	53	40	33	28	25	23	21	18	16	12	1
.30	8	11	14	19	21	24	29	38	53	76	108	148	190	263	288	268	224	177	140	101	76	55	41	34	29	25	23	21	18	16	12	2
.40	8	10	13	18	20	23	27	34	46	66	94	130	170	245	282	273	235	188	149	107	80	58	42	34	29	26	23	21	19	16	12	2
.50	7	9	12	16	17	19	22	25	31	41	58	82	114	190	256	279	262	222	178	127	93	65	46	36	31	27	24	22	19	17	13	2
.75	6	8	10	14	15	17	19	21	25	31	41	56	78	139	207	254	265	245	208	152	110	75	51	39	32	28	25	22	19	17	13	3
1.0	5	6	8	10	11	13	14	15	17	19	22	26	33	60	109	173	230	261	255	208	153	100	64	46	36	30	26	24	20	18	13	5
1.5	3	4	5	7	7	8	9	9	10	11	12	13	15	19	27	45	79	130	186	247	239	180	108	68	48	37	31	27	22	19	14	10
2.0	2	3	4	5	6	6	7	7	8	8	9	10	11	13	16	22	35	59	98	171	236	236	156	95	62	44	35	30	23	20	15	11
2.5	1	2	2	3	4	4	4	5	5	5	6	6	7	8	10	12	14	19	28	58	114	197	226	163	102	65	46	36	26	21	16	11
3.0	0	1	1	2	2	2	2	3	3	3	4	4	4	5	6	7	9	10	13	19	35	88	184	218	169	109	70	49	31	24	18	12

IA/P = 0.30 * * * TC = 1.25 HR * * * IA/P = 0.30

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	0	2	9	25	50	86	130	174	208	253	235	201	164	136	115	92	76	61	51	44	39	35	32	30	27	24	19	1
.10	0	0	0	0	0	0	1	6	19	40	71	110	153	217	247	227	191	157	131	103	84	66	53	46	41	36	33	31	28	24	19	2
.20	0	0	0	0	0	0	1	4	14	31	58	93	133	202	239	231	199	165	138	108	87	68	55	47	41	37	33	31	28	25	19	2
.30	0	0	0	0	0	0	0	1	3	10	24	46	77	152	210	236	222	190	158	122	97	74	58	49	43	38	34	32	28	25	20	3
.40	0	0	0	0	0	0	0	0	2	8	19	37	64	134	196	232	225	198	166	127	101	77	59	50	43	38	35	32	28	25	20	3
.50	0	0	0	0	0	0	0	0	0	2	6	14	30	82	151	206	228	217	189	146	113	85	64	52	45	40	36	33	29	26	20	5
.75	0	0	0	0	0	0	0	0	0	1	2	7	15	49	105	164	205	218	205	166	129	95	69	55	47	41	37	33	29	26	20	6
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	32	77	134	185	214	203	166	120	83	63	52	45	39	35	30	27	21	10
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	33	72	121	184	203	171	117	82	62	51	44	39	32	29	22	15
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	21	67	132	194	174	123	86	64	52	45	35	31	24	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	46	121	187	166	119	84	63	52	39	32	25	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	44	129	180	160	116	83	63	44	35	27	18

IA/P = 0.50 * * * TC = 1.25 HR * * * IA/P = 0.50

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	0	0	1	5	13	26	44	68	91	125	142	142	128	117	107	94	83	72	63	57	52	47	44	42	38	34	28	2
.10	0	0	0	0	0	0	0	0	3	10	20	36	57	100	129	140	136	125	114	100	88	76	65	59	54	49	45	43	39	35	29	3
.20	0	0	0	0	0	0	0	0	2	7	16	30	48	90	122	139	139	127	117	102	90	77	66	60	54	49	45	43	39	35	29	3
.30	0	0	0	0	0	0	0	0	0	2	5	12	24	59	98	126	137	134	125	109	96	82	69	61	56	51	46	44	40	36	29	4
.40	0	0	0	0	0	0	0	0	0	1	4	10	19	51	89	119	134	136	127	112	98	83	70	62	56	51	47	44	40	36	29	5
.50	0	0	0	0	0	0	0	0	0	1	3	7	15	43	79	112	131	135	129	114	100	85	71	63	57	52	47	44	40	36	29	6
.75	0	0	0	0	0	0	0	0	0	0	0	1	3	15	39	71	102	123	130	125	112	94	78	67	60	54	49	46	41	37	29	9
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	17	40	71	101	121	129	121	103	84	71	62	56	51	47	42	38	30	13
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	26	51	92	119	125	105	86	72	63	57	52	44	40	32	23
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	35	72	112	122	103	85	71	63	56	47	42	34	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	24	66	111	119	101	83	71	62	51	44	36	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	23	71	110	116	99	82	70	55	46	37	27

RAINFALL TYPE = II * * * TC = 1.25 HR * * * SHEET 8 OF 10

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

HYDROGRAPH TIME (HOURS)

IA/P = 0.10 * * * TC = 1.5 HR * * * IA/P = 0.10

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	9	11	15	21	25	31	41	58	82	112	147	184	216	255	275	236	198	159	129	98	76	57	43	35	30	25	23	21	18	16	12	1
.10	8	10	13	18	20	23	28	37	51	72	98	131	166	226	265	254	226	187	151	113	86	63	46	37	31	26	23	21	19	16	13	2
.20	8	10	13	17	19	22	26	33	45	63	87	116	149	212	259	259	233	197	160	119	90	66	48	38	32	27	24	22	19	16	13	2
.30	7	9	12	16	18	21	24	30	40	55	76	103	134	197	244	255	238	206	169	125	95	68	49	38	32	27	24	22	19	17	13	2
.40	7	8	11	14	15	17	19	23	28	36	49	67	91	151	208	247	252	230	196	146	109	77	54	41	34	29	25	22	19	17	13	3
.50	6	8	10	13	15	16	18	21	26	33	43	59	80	136	194	238	249	235	204	154	115	81	56	42	34	29	25	23	20	17	13	3
.75	5	7	8	11	12	13	14	16	18	21	25	32	42	76	125	179	222	240	233	193	148	102	67	48	38	32	27	24	20	18	13	5
1.0	4	5	7	8	9	10	11	12	13	14	16	18	22	34	59	101	152	201	236	230	193	135	86	59	44	35	30	26	21	18	14	7
1.5	3	4	5	6	6	7	8	8	9	10	11	12	13	16	22	34	58	95	141	203	226	197	131	84	58	43	35	29	23	20	15	10
2.0	1	2	3	4	4	5	5	6	6	7	7	8	9	10	12	16	22	34	56	110	172	218	187	126	82	57	43	34	25	21	16	11
2.5	1	1	2	2	3	3	3	4	4	4	5	5	6	7	8	9	11	14	18	34	69	141	210	190	133	87	60	44	30	23	17	12
3.0	0	0	1	1	2	2	2	2	3	3	3	3	4	5	5	6	8	9	11	16	27	66	149	204	181	128	85	58	35	25	18	12

IA/P = 0.30 * * * TC = 1.5 HR * * * IA/P = 0.30

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	0	1	6	15	31	53	80	112	144	193	225	208	186	157	134	108	89	70	56	48	42	37	34	31	28	25	20	2
.10	0	0	0	0	0	0	1	4	12	25	43	68	97	157	198	219	203	178	151	120	98	77	60	50	44	38	35	32	28	25	20	3
.20	0	0	0	0	0	0	0	1	3	9	19	35	57	114	168	201	213	196	171	135	108	84	64	53	46	40	36	33	29	26	20	4
.30	0	0	0	0	0	0	0	1	2	7	15	29	48	100	155	193	210	200	177	140	113	87	66	54	46	41	36	33	29	26	20	5
.40	0	0	0	0	0	0	0	0	2	5	12	23	39	87	141	184	207	202	182	146	117	89	68	55	47	41	36	33	29	26	20	5
.50	0	0	0	0	0	0	0	0	0	1	4	9	18	51	101	153	190	205	197	164	131	99	73	58	49	43	38	34	30	26	20	7
.75	0	0	0	0	0	0	0	0	0	0	2	4	9	30	68	116	160	189	197	179	147	110	80	62	52	45	39	35	30	27	21	8
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	20	49	92	138	175	195	178	137	97	72	57	48	42	37	31	28	21	12
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	21	47	85	145	187	178	133	95	71	57	48	42	34	29	23	16
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	45	97	162	180	138	99	74	58	49	38	32	25	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	31	89	161	174	133	97	72	58	42	34	26	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	29	98	160	169	129	95	71	48	37	28	19

IA/P = 0.50 * * * TC = 1.5 HR * * * IA/P = 0.50

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
.0	0	0	0	0	0	0	0	3	8	16	27	42	59	92	116	128	130	121	112	100	90	78	67	60	55	50	46	43	39	35	29	4
.10	0	0	0	0	0	0	0	2	6	12	22	35	51	84	110	125	128	123	114	102	91	79	68	61	55	50	46	43	39	35	29	4
.20	0	0	0	0	0	0	0	0	1	4	10	18	29	60	91	114	126	128	120	108	97	83	71	63	57	52	47	44	40	36	29	5
.30	0	0	0	0	0	0	0	0	1	3	8	14	24	52	83	108	123	126	122	110	98	85	72	63	57	52	48	44	40	36	29	6
.40	0	0	0	0	0	0	0	0	0	1	2	6	12	31	60	90	112	124	126	116	104	90	75	66	59	54	49	45	41	37	29	8
.50	0	0	0	0	0	0	0	0	0	0	2	4	9	26	53	83	106	121	125	118	106	91	77	67	60	54	49	46	41	37	29	8
.75	0	0	0	0	0	0	0	0	0	0	1	2	5	16	36	62	88	108	119	122	112	97	81	69	62	56	51	47	42	38	30	11
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	26	49	75	98	118	121	108	90	76	66	59	54	49	43	39	31	16
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	25	45	80	107	118	106	89	75	65	59	53	45	41	32	23
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	32	63	100	115	104	87	74	65	58	48	42	34	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	16	48	94	113	105	89	76	66	53	45	36	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	15	54	96	111	103	88	75	58	48	38	28

RAINFALL TYPE = II * * * TC = 1.5 HR * * * SHEET 9 OF 10

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

HYDROGRAPH TIME (HOURS)

IA/P = 0.10 * * * TC = 2.0 HR * * * IA/P = 0.10

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	7	9	12	16	18	21	27	36	49	64	82	104	127	171	201	226	208	193	171	132	105	79	58	45	36	30	26	23	20	17	13	3
.10	6	8	10	14	15	17	20	25	33	43	57	74	94	139	179	204	218	205	188	150	118	88	63	48	38	32	27	24	20	17	13	4
.20	6	8	10	13	14	16	19	23	29	39	51	66	84	128	169	198	213	207	192	157	123	91	65	49	39	33	28	24	20	17	13	4
.30	6	7	9	12	14	15	18	21	27	35	45	59	76	117	159	191	211	208	196	163	128	95	68	51	40	33	28	25	20	18	13	4
.40	5	6	8	11	12	13	15	17	20	24	31	41	53	87	128	167	197	209	205	180	145	106	75	55	43	35	30	26	21	18	14	5
.50	5	6	8	10	11	13	14	16	18	22	28	37	48	78	118	158	190	208	208	185	151	111	77	57	44	36	30	26	21	18	14	5
.75	4	6	7	9	10	11	12	13	15	18	22	27	35	58	91	129	164	191	202	194	167	125	87	63	48	38	32	27	22	18	14	6
1.0	3	4	6	7	8	8	9	10	11	12	14	16	18	28	46	74	110	147	178	201	193	156	108	76	56	43	35	30	23	19	14	8
1.5	2	3	3	5	5	5	6	6	7	8	8	9	10	12	16	23	36	57	86	137	178	195	160	113	79	58	45	36	26	21	16	11
2.0	1	2	2	3	3	4	4	4	5	5	6	6	7	8	10	12	16	23	35	67	112	169	190	154	110	78	57	44	30	23	17	11
2.5	0	1	1	2	2	2	3	3	3	4	4	4	5	6	7	8	9	12	16	28	52	105	170	185	149	107	76	56	35	26	18	12
3.0	0	0	1	1	1	1	1	2	2	2	2	3	3	3	4	5	6	7	8	12	18	41	99	161	180	152	112	80	45	30	19	12

IA/P = 0.30 * * * TC = 2.0 HR * * * IA/P = 0.30

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	0	1	3	8	15	25	38	54	74	115	148	168	185	170	159	131	110	89	70	57	49	42	38	34	29	26	20	5
.10	0	0	0	0	0	0	0	2	6	12	21	32	47	85	124	153	169	180	168	145	120	96	75	60	51	44	39	35	30	26	20	6
.20	0	0	0	0	0	0	0	2	4	10	17	27	41	75	114	146	165	175	170	149	124	99	76	62	52	45	39	35	30	27	21	6
.30	0	0	0	0	0	0	0	0	1	3	7	14	23	49	86	122	151	170	174	160	136	107	82	66	54	47	41	37	31	27	21	8
.40	0	0	0	0	0	0	0	0	1	2	6	11	19	43	77	113	144	165	173	163	140	111	85	67	55	47	41	37	31	27	21	8
.50	0	0	0	0	0	0	0	0	1	2	4	9	16	37	68	104	136	160	171	165	144	114	87	69	56	48	42	37	31	27	21	9
.75	0	0	0	0	0	0	0	0	0	0	1	2	5	15	34	62	96	127	152	167	160	132	100	77	62	52	45	40	32	28	22	11
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	24	48	79	111	150	166	153	118	90	71	58	49	43	34	29	23	14
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	24	45	88	130	161	148	115	88	70	57	48	37	31	24	17
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	32	68	122	157	143	113	87	68	56	42	34	26	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	16	51	114	153	144	116	89	70	49	38	27	19
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	15	59	118	150	140	113	88	57	42	29	19

IA/P = 0.50 * * * TC = 2.0 HR * * * IA/P = 0.50

TRVL TIME (hr)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	0	0	0	1	4	8	13	20	28	51	73	92	104	111	112	106	97	86	75	66	60	54	49	46	41	37	30	7
.10	0	0	0	0	0	0	0	1	3	6	11	17	24	45	68	87	101	109	112	107	98	88	76	67	60	55	50	46	41	37	30	8
.20	0	0	0	0	0	0	0	1	2	5	9	14	21	40	62	82	98	107	111	108	100	89	77	68	61	55	50	47	41	37	30	8
.30	0	0	0	0	0	0	0	0	0	2	4	7	12	26	46	67	86	100	108	111	104	93	80	70	63	57	52	48	42	38	30	10
.40	0	0	0	0	0	0	0	0	0	1	3	6	10	22	41	62	81	96	106	110	105	94	81	71	63	57	52	48	42	38	30	11
.50	0	0	0	0	0	0	0	0	0	0	1	2	4	13	27	46	67	85	99	110	108	98	85	74	66	59	54	49	43	39	31	13
.75	0	0	0	0	0	0	0	0	0	0	0	1	2	7	18	33	52	71	88	104	108	102	89	77	68	61	55	50	44	39	31	15
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	25	43	62	87	103	108	97	84	73	65	59	53	45	41	32	20
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	12	24	48	74	99	106	95	83	72	64	58	48	43	34	25
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	17	37	69	99	104	94	82	72	64	52	45	36	27
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	27	65	95	102	95	83	73	58	49	38	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	32	68	95	101	93	82	64	52	40	28

RAINFALL TYPE = II * * * TC = 2.0 HR * * * SHEET 10 OF 10

APPENDIX B; INFRASTRUCTURE TABLE FOR RESEARCH STUDY AREA

CatchID	PatchID	SurfTyID	Area	Length	Slope	Pond
1	1	2	0.013139	186	0.096774	0
1	2	4	0.004031	1377	0.002905	0
1	3	4	0.040194	2239	0.00268	0
1	4	3	0.00268	440	0.009091	0
1	5	3	0.002156	811	0.004932	0
1	6	4	0.018104	1653	0.00726	0
1	7	2	0.011344	2085	0.003837	0
1	8	3	0.010442	448	0.013393	0
1	9	4	0.019872	1231	0.003249	0
1	11	5	0.033199	2056	0.004864	0
1	10	5	0.006243	861	0.002323	0
2	1	4	0.139246	2950	0.000678	0
2	2	5	0.124964	3480	0.001149	0
2	3	3	0.004358	822	0.002433	0
3	1	5	0.084438	1933	0.003104	0
3	2	3	0.013156	264	0.007576	0
3	3	4	0.105516	1862	0.002148	0
3	4	3	0.004686	894	0.004474	0
4	1	4	0.158473	3204	0.002809	0
4	2	5	0.218056	3720	0.003763	0
4	3	3	0.010133	711	0.002813	0
5	2	3	0.011288	1103	0.003626	0
5	3	4	0.044721	1806	0.003322	0
5	4	5	0.019653	1000	0.003	0
5	1	4	0.154808	3926	0.00433	0
6	1	5	0.044393	1873	0.003203	0
6	2	3	0.009267	913	0.002191	0
6	3	5	0.061124	1451	0.004135	0
6	4	4	0.044461	1636	0.002445	0
6	5	5	0.041394	907	0.006615	0
6	6	3	0.013594	1116	0.005376	0
7	1	4	0.020104	1082	0.003697	0
7	2	5	0.057384	1502	0.002663	0
7	3	3	0.004193	540	0.003704	0
7	4	4	0.079814	2038	0.002944	0
8	1	4	0.154	3181	0.003772	0
8	2	1	0.000623	100	0.02	0
9	1	4	0.073502	1584	0.003788	0
9	2	3	0.002533	537	0.001862	0
9	3	2	0.001088	365	0.00274	0
10	1	4	0.089778	1836	0.006536	0
10	2	2	0.001173	181	0.011042	0
11	1	4	0.04235	1176	0.005102	0

11	2	6	0.013453	654	0.006118	0
11	3	5	0.025047	1074	0.007451	0
11	4	4	0.008826	531	0.011295	0
11	5	2	0.000647	134	0.007437	0
12	1	4	0.019442	1016	0.007877	0
12	2	2	0.008775	764	0.007852	0
12	3	6	0.01666	820	0.00732	0
12	4	4	0.017028	858	0.006997	0
12	5	3	0.009022	710	0.008446	0
12	6	4	0.079079	1758	0.004551	0
12	7	3	0.003625	320	0.006257	0
13	1	5	0.125831	2119	0.004718	0
13	2	3	0.004366	440	0.004544	0
13	3	2	0.003075	312	0.003202	0
14	1	4	0.018177	925	0.006486	0
14	2	2	5.76E-05	48	0.02099	0
15	1	3	0.115433	1872	0.004274	0
15	2	4	0.014	1013	0.005921	0
15	3	4	0.000893	162	0.006169	0
16	1	3	0.01305	604	0.001655	0
16	2	4	0.133227	2465	0.00649	0
16	3	5	0.03127	998	0.008016	0
17	1	5	0.028909	1096	0.010952	0
17	2	3	0.008903	741	0.013497	0
17	3	4	0.049138	1687	0.003558	0
17	4	2	0.01864	838	0.004772	0
18	1	4	0.015329	1516	0.005278	0
18	2	2	0.006914	1449	0.005523	0
19	1	5	0.019152	737	0.008146	0
19	2	4	0.046356	1412	0.002834	0
19	3	2	0.005077	422	0.004742	0
20	1	4	0.014124	678	0.008848	0
20	2	6	0.002416	261	0.003834	0
20	3	4	0.007583	498	0.008033	0
20	4	4	0.00701	457	0.008762	0
20	5	3	0.00082	171	0.005852	0
21	1	4	0.031337	1094	0.001829	0
21	2	3	0.005643	735	0.00272	0
22	1	4	0.020426	781	0.005123	0
22	2	5	0.005672	542	0.007378	0
22	3	4	0.021941	789	0.0076	0
22	4	4	0.03855	1133	0.005294	0
22	5	3	0.000203	80	0.012424	0
23	1	4	0.078341	2071	0.004828	0
23	2	3	0.000732	156	0.006402	0
24	1	4	0.042208	1180	0.003389	0

24	2	4	0.02482	844	0.007108	0
24	3	5	0.023004	809	0.002471	0
24	4	3	0.000625	135	0.007381	0
25	1	4	0.056371	1550	0.003871	0
25	2	2	0.002768	287	0.003488	0
25	3	5	0.008724	515	0.001941	0
25	4	4	0.017088	691	0.004343	0
26	1	4	0.03512	983	0.004069	0
26	2	3	0.014657	1538	0.002601	0
26	3	4	0.015886	939	0.004258	0
27	1	4	0.005728	458	0.004364	0
27	2	3	0.001508	249	0.004012	0
27	3	6	0.00387	379	0.010544	0
27	4	4	0.025681	1069	0.00374	0
27	5	3	0.002385	274	0.014619	0
27	6	6	0.003961	418	0.007175	0
27	7	5	0.042573	1224	0.006538	0
28	1	3	0.006904	635	0.00315	0
28	2	4	0.020479	932	0.004292	0
28	3	2	0.006942	704	0.008525	0
28	4	4	0.022287	836	0.007173	0
28	5	5	0.021407	784	0.005105	0
29	1	4	0.01667	819	0.007327	0
29	2	4	0.048892	1171	0.004268	0
29	3	3	0.004955	704	0.005681	0
30	1	5	0.044715	1276	0.004702	0
30	2	4	0.00641	592	0.010136	0
30	3	3	0.004243	513	0.007791	0
31	1	4	0.031542	1032	0.007756	0
31	2	3	0.001995	368	0.010861	0
32	1	4	0.045997	1252	0.006389	0
32	2	3	0.006922	448	0.008938	0
33	1	4	0.03898	1059	0.005665	0
33	2	3	0.000938	231	0.004334	0
34	1	4	0.045869	1174	0.003407	0
34	2	3	0.000719	213	0.004688	0
35	1	4	0.045184	1157	0.004321	0
35	2	3	3.18E-05	41	0.024098	0
36	1	4	0.053412	1501	0.002664	0
36	2	3	0.001412	243	0.004119	0
36	3	3	0.001641	218	0.022912	0
36	4	1	0.004502	357	0.016797	0
37	1	4	0.043016	1102	0.005446	0
37	2	3	7.80E-05	53	0.018708	0
38	1	4	0.018654	722	0.005539	0
38	2	3	0.002259	394	0.002537	0

38	3	4	0.031301	971	0.004121	0
39	1	4	0.141008	2001	0.003998	0
39	2	3	6.05E-05	50	0.019823	0
40	1	4	0.097054	1709	0.007023	0
40	2	3	0.000756	181	0.005517	0
41	1	4	0.097794	1669	0.005992	0
41	2	3	0.000109	63	0.015802	0
42	1	4	0.12066	2183	0.00458	0
42	2	3	0.017507	700	0.002858	0
42	3	4	0.007252	499	0.008018	0
42	4	5	0.004913	614	0.00651	0
43	1	4	0.072709	1425	0.004212	0
43	2	3	0.001959	325	0.00308	0
44	1	4	0.035788	1063	0.005645	0
44	2	3	0.001901	273	0.003658	0
45	1	4	0.068339	1381	0.002895	0
45	2	3	4.11E-05	48	0.020758	0
46	1	4	0.137059	2204	0.002723	0
46	2	2	0.004073	522	0.001915	0
46	3	3	0.001811	416	0.002402	0
46	4	2	0.002066	355	0.002819	0
47	1	5	0.021257	755	0.001325	0
47	2	5	0.043471	1302	0.001536	0
47	3	4	0.005973	508	0.00197	0
47	4	4	0.022172	953	0.002099	0
47	5	3	0.053935	3069	0.001955	0
48	1	4	0.315894	2969	0.004042	0
48	2	3	0.002594	271	0.003689	0
49	1	2	0.112766	2039	0.004904	0
50	1	2	0.018221	795	0.002516	0
50	2	4	0.108128	2059	0.003884	0
51	1	4	0.028984	935	0.006415	0
51	2	2	0.001706	337	0.014852	0
52	1	4	0.063462	1360	0.004412	0
52	2	3	4.95E-05	43	0.023123	0
53	1	4	0.020325	804	0.006216	0
53	2	3	1.47E-05	25	0.040339	0
54	1	4	0.049791	1180	0.004237	0
54	2	3	2.19E-05	29	0.034491	0
55	1	4	0.048358	1191	0.00252	0
55	2	3	4.97E-05	43	0.023088	0
56	1	4	0.070277	1528	0.003928	0
56	2	3	0.003292	426	0.00235	0
57	1	4	0.038381	1166	0.005145	0
57	2	3	0.001118	196	0.010222	0
58	1	4	0.076213	1914	0.002612	0

58	2	3	3.42E-05	36	0.027624	0
59	1	4	0.064405	1890	0.002117	0
59	2	2	0.008632	1271	0.001573	0
60	1	4	0.073173	1784	0.001121	0
60	2	2	0.001401	200	0.005011	0
60	3	3	0.001657	223	0.004493	0
60	4	3	0.001947	244	0.004095	0
60	5	3	0.00118	266	0.003755	0
61	1	4	0.082407	1518	0.001977	0
61	2	3	0.00034	97	0.010339	0
62	1	4	0.082076	1515	0.00198	0
62	2	3	0.00011	56	0.017717	0
63	1	4	0.030258	1279	0.002346	0
63	2	3	0.00168	237	0.004212	0
63	3	3	0.00628	515	0.003884	0
63	4	4	0.035974	1535	0.002606	0
63	5	3	0.003178	304	0.003289	0
64	1	4	0.059466	1298	0.003852	0
64	2	3	0.000464	134	0.00746	0
65	1	4	0.034645	1050	0.003811	0
65	2	3	3.58E-05	37	0.02715	0
66	1	4	0.034347	1042	0.002879	0
66	2	3	3.21E-05	40	0.02497	0
67	1	4	0.074153	1438	0.002086	0
67	2	3	3.67E-05	37	0.026954	0
68	1	4	0.070946	1406	0.001422	0
68	2	3	0.00047	142	0.007062	0
69	1	4	0.063027	1409	0.002129	0
69	2	3	0.008527	534	0.003746	0
70	1	4	0.023862	816	0.003675	0
70	2	3	2.61E-05	33	0.030741	0
71	1	4	0.018209	715	0.001398	0
71	2	3	1.09E-05	22	0.044714	0
72	1	4	0.019859	736	0.001358	0
72	2	3	0.000351	119	0.008416	0
73	1	4	0.015201	652	0.001534	0
73	2	3	1.14E-05	22	0.045564	0
74	1	4	0.021997	786	0.001271	0
74	2	3	1.20E-05	21	0.04716	0
75	1	4	0.012641	700	0.004288	0
75	2	3	0.003709	415	0.007224	0
76	1	4	0.014481	951	0.002104	0
76	2	3	0.005713	467	0.00214	0
76	3	4	0.010917	557	0.001796	0
76	4	3	0.002889	374	0.002676	0
77	1	4	0.040242	1131	0.002653	0

77	2	3	0.000622	161	0.006206	0
78	1	4	0.038088	1250	0.0016	0
78	2	3	0.00168	217	0.004601	0
79	1	4	0.039596	1141	0.005258	0
79	2	3	3.83E-05	39	0.025593	0
80	1	4	0.050857	1223	0.004087	0
80	2	3	2.38E-05	33	0.030643	0
81	1	4	0.091557	1706	0.004688	0
81	2	3	7.18E-06	16	0.060877	0
82	1	4	0.023081	842	0.005935	0
82	2	3	6.79E-05	53	0.019034	0
83	1	4	0.111192	1958	0.002043	0
83	2	3	0.010628	1057	0.005678	0
84	1	4	0.106159	2168	0.00369	0
84	2	2	0.020299	1732	0.009239	0
85	1	4	0.035721	1012	0.005928	0
85	2	3	0.006067	582	0.010313	0
86	1	4	0.075169	1448	0.005526	0
86	2	3	2.42E-05	35	0.028501	0
87	1	4	0.07177	1415	0.006362	0
87	2	3	5.11E-05	43	0.023094	0
88	1	4	0.071953	1417	0.006353	0
88	2	3	0.000282	100	0.010023	0
89	1	4	0.015361	655	0.003054	0
89	2	3	1.97E-05	27	0.037027	0
90	1	4	0.015077	649	0.001542	0
90	2	3	1.79E-05	25	0.039233	0
91	1	4	0.015349	654	0.001528	0
91	2	3	1.39E-05	23	0.044217	0
92	1	4	0.013702	619	0.001615	0
92	2	3	2.59E-05	31	0.032584	0
93	1	4	0.015259	655	0.001528	0
93	2	3	6.48E-06	18	0.056511	0
94	1	4	0.015945	667	0.001499	0
94	2	3	0.000271	153	0.006543	0
95	1	4	0.036176	1091	0.001833	0
95	2	3	0.00105	191	0.005245	0
96	1	4	0.035022	1073	0.002797	0
96	2	3	0.000357	124	0.008036	0
97	1	4	0.076352	1716	0.003497	0
97	2	3	0.000187	85	0.011794	0
98	1	4	0.125939	1931	0.004142	0
98	2	5	0.009662	559	0.010741	0
98	3	3	0.001815	307	0.013021	0
98	4	3	0.012103	715	0.027958	0
99	1	4	0.031272	1129	0.003542	0

99	2	0	9.20E-05	58	0.017116	0
100	1	4	0.07982	1510	0.00795	0
100	2	3	0.00043	132	0.015185	0
101	1	4	0.115903	1940	0.009277	0
101	2	3	0.002335	276	0.007248	0
102	1	4	0.014419	686	0.011664	0
102	2	3	0.00187	282	0.007101	0
102	3	4	0.021949	865	0.009247	0
103	1	4	0.022591	1015	0.005914	0
103	2	3	3.31E-05	41	0.024146	0
104	1	4	0.01229	932	0.00429	0
104	2	4	0.034958	2173	0.002761	0
104	3	3	0.003682	377	0.010619	0
104	4	3	0.00476	458	0.004368	0
104	5	3	0.009189	1073	0.007454	0
105	1	4	0.172709	2403	0.002497	0
105	2	3	0.008084	603	0.016574	0
105	3	4	0.031693	1116	0.005379	0
106	1	4	0.075299	1475	0.004068	0
106	2	3	0.000234	98	0.010243	0
107	1	4	0.060281	1332	0.003004	0
107	2	3	0.000518	125	0.008005	0
108	1	3	0.037889	1016	0.005905	0
108	2	4	0.061858	1994	0.004011	0
108	3	4	0.022349	1246	0.006419	0
109	1	4	0.210837	2565	0.010918	0
109	2	3	0.000585	141	0.014164	0
110	1	4	0.060561	1280	0.006251	0
110	2	3	0.00321	363	0.01652	0
111	1	5	0.099608	1749	0.004573	0
111	2	3	0.000522	144	0.027822	0
112	1	4	0.111492	1808	0.003318	0
112	2	3	7.26E-05	52	0.019095	0
113	1	4	0.109751	1795	0.004456	0
113	2	3	5.95E-05	47	0.021308	0
114	1	4	0.119385	1870	0.004278	0
114	2	3	5.34E-05	44	0.02252	0
115	1	4	0.111575	1811	0.004417	0
115	2	3	7.03E-05	52	0.0194	0
116	1	4	0.043616	1109	0.00541	0
116	2	3	0.045852	1308	0.004585	0
116	3	3	0.033881	1280	0.00625	0
116	4	3	0.026939	1172	0.006829	0
116	5	3	0.022204	1311	0.012206	0
117	1	4	0.112904	2288	0.006994	0
117	2	3	0.133749	2292	0.004364	0

118	1	4	0.113489	1819	0.004398	0
118	2	3	9.90E-05	61	0.016429	0
119	1	4	0.059886	1491	0.005366	0
119	2	4	0.019051	729	0.005486	0
119	3	3	0.014075	629	0.006359	0
119	4	4	0.021151	775	0.010323	0
120	1	4	0.058735	1539	0.006498	0
120	2	3	0.009725	536	0.011195	0
121	1	4	0.027896	1043	0.005753	0
121	2	3	0.003083	294	0.017015	0
122	1	4	0.06564	1601	0.008744	0
122	2	3	0.005882	409	0.014671	0
123	1	4	0.075142	1448	0.011053	0
123	2	3	0.000147	77	0.012979	0
124	1	4	0.072013	1417	0.012702	0
124	2	3	2.15E-05	28	0.035189	0
125	1	4	0.072136	1418	0.016923	0
125	2	3	3.51E-05	37	0.027377	0
126	1	4	0.075326	1450	0.013796	0
126	2	3	2.64E-05	32	0.031261	0
127	1	4	0.033617	1067	0.014994	0
127	2	3	0.001352	196	0.03059	0
128	1	4	0.035566	1071	0.009338	0
128	2	3	2.3E-05	30	0.033206	0
129	1	4	0.03315	1040	0.005769	0
129	2	3	2.57E-05	32	0.031354	0
130	1	4	0.031409	1005	0.005972	0
130	2	3	2.45E-05	36	0.027889	0
131	1	4	0.031987	1017	0.004915	0
131	2	3	5.04E-05	44	0.022762	0
132	1	4	0.034872	1057	0.005676	0
132	2	3	1.62E-05	26	0.038301	0
133	1	4	0.032561	1020	0.005883	0
133	2	3	1.13E-05	22	0.045594	0
134	1	4	0.086298	2298	0.003482	0
134	2	2	0.038062	1336	0.007485	0
134	3	1	0.014805	795	0.01258	0
134	4	3	0.002258	437	0.009155	0
135	1	4	0.100357	1714	0.010501	0
135	2	3	0.001299	243	0.012363	0
136	1	4	0.102742	1770	0.009038	0
136	2	3	6.00E-05	49	0.020361	0
137	1	4	0.045851	1406	0.002845	0
137	2	3	0.00277	378	0.002644	0
137	3	3	0.045211	1640	0.004879	0
137	4	4	0.079187	1703	0.002349	0

137	5	4	0.019983	752	0.001329	0
137	6	3	0.013302	1328	0.006024	0
137	7	4	0.006487	585	0.006834	0
138	1	4	0.098441	1758	0.003412	0
138	2	3	0.001349	204	0.004902	0
139	1	4	0.063318	1478	0.00406	0
139	2	3	0.000458	141	0.007111	0
140	1	3	0.029384	1212	0.003301	0
140	2	4	0.000458	188	0.00533	0
141	1	3	0.052726	2126	0.004703	0
141	2	4	0.009537	769	0.005199	0
142	1	3	0.032622	1302	0.006145	0
142	2	4	0.001359	268	0.003731	0
143	1	4	0.04278	1080	0.007406	0
143	2	4	0.015045	1200	0.005001	0
143	3	3	0.031635	1541	0.006488	0
143	4	1	0.008118	882	0.006802	0
143	5	1	0.005144	729	0.01098	0
144	1	4	0.034391	1001	0.005996	0
144	2	3	0.009214	545	0.001835	0
145	1	4	0.029922	1018	0.011783	0
145	2	3	0.00059	183	0.010959	0
146	1	4	0.036152	1060	0.015087	0
146	2	3	0.006667	728	0.021986	0
147	1	4	0.069056	1388	0.011528	0
147	2	3	0.001083	204	0.009822	0
148	1	4	0.062959	1400	0.009999	0
148	2	3	0.003208	298	0.02011	0
148	3	3	0.005913	461	0.013027	0
149	1	4	0.040552	1202	0.003327	0
149	2	3	0.011726	864	0.013895	0
149	3	3	0.005215	472	0.012711	0
149	4	3	0.004783	461	0.008669	0
150	1	4	0.034358	1064	0.024447	0
150	2	3	0.000942	210	0.009546	0
151	1	4	0.045751	1425	0.015443	0
151	2	3	0.00262	352	0.011352	0
152	1	4	0.067714	1672	0.007176	0
152	2	3	0.002609	300	0.020027	0
153	1	4	0.074762	1472	0.008153	0
153	2	3	0.000105	65	0.015321	0
154	1	4	0.075364	1451	0.011027	0
154	2	3	6.57E-05	51	0.019716	0
155	1	4	0.01716	860	0.018614	0
155	2	3	0.000563	138	0.007254	0
156	1	4	0.054586	1300	0.013844	0

156	2	3	0.004087	403	0.014906	0
157	1	6	0.083874	1761	0.002272	0
157	2	4	0.005819	552	0.003626	0
157	3	3	0.002639	361	0.005535	0
157	4	4	0.010217	587	0.010224	0
158	1	4	0.033378	1064	0.011281	0
158	2	3	0.009492	529	0.001891	0
158	3	4	0.034367	1126	0.005326	0
159	1	4	0.036063	1139	0.007024	0
159	2	2	0.015927	901	0.008879	0
160	1	4	0.051071	1219	0.004922	0
160	2	3	0.011224	879	0.009102	0
160	3	4	0.037302	1134	0.008822	0
160	4	3	0.019098	868	0.008065	0
161	1	3	0.087399	1571	0.005093	0
161	2	4	0.016062	939	0.008516	0
162	1	4	0.057051	1784	0.003363	0
162	2	3	0.015379	657	0.006091	0
163	1	4	0.077491	1743	0.003443	0
163	2	3	0.021842	951	0.004208	0
163	3	3	0.001371	205	0.004887	0
164	1	4	0.09096	1698	0.002356	0
164	2	3	0.00387	387	0.002584	0
165	1	4	0.056016	1296	0.004629	0
165	2	3	0.011827	587	0.013617	0
165	3	4	0.064442	1577	0.005072	0
165	4	3	0.039318	1770	0.011302	0
166	1	4	0.220825	2427	0.004944	0
166	2	3	0.044681	1441	0.011101	0

APPENDIX C

Total Peak Discharge for Study Area (cfs)						
Percipitation (in)	1	2	2.5	3	4	5
Current Landscape	1476	3717	4892	6088	8507	10945
5% Green Infrastructure	1309	3499	4651	5840	8242	10667
10% Green Infrastructure	1160	3297	4433	5610	7995	10409
15% Green Infrastructure	1032	3107	4225	5387	7753	10154
20% Green Infrastructure	911	2922	4025	5173	7517	9903
10% reduction	1328	3345	4403	5479	7657	9850
20% reduction	1181	2973	3914	4870	6806	8756

Total Runoff Volume for Study Area (cfs)						
Percipitation (in.)	1	2	2.5	3	4	5
Current Landscape	106	258	337	417	579	742
5% Green Infrastructure	93	242	320	399	560	723
10% Green Infrastructure	83	227	304	383	542	704
15% Green Infrastructure	73	213	289	366	525	686
20% Green Infrastructure	65	200	274	351	508	667